AMERICAN SPIDERS

AND

THEIR SPINNINGWORK.

A NATURAL HISTORY

OF THE

ORBWEAVING SPIDERS OF THE UNITED STATES

WITH SPECIAL REGARD TO THEIR INDUSTRY AND HABITS.

BY

HENRY C. McCOOK, D. D.,

Vice-President of the Academy of Natural Sciences of Philadelphia;
Vice-President of the American Entomological Society;
Author of "The Agricultural Ants of Texas,"
"The Honey and Occident Ants,"
etc., etc.

VOL. II.

PUBLISHED BY THE AUTHOR,
Academy of Natural Sciences of Philadelphia.
A. D. 1890.

AUTHOR'S EDITION.

This Edition is limited to Two HUNDRED AND FIFTY copies, of which this set is

SUBSCRIPTION NO. 40

AUTHOR'S SIGNATURE, Henry C. McCook

THE PRESS OF
ALLEN, LANE & SCOTT,
PHILADELPHIA.

PREFACE.

WITH the completion of the second volume of "American Spiders and their Spinningwork," I feel that I have substantially ended the task which many years ago I proposed to myself. That task, as it lay in my purpose, was the description and illustration, in as large detail as possible, of the spinning industry and general habits of true spiders.

Subsequently, as announced in the first volume of this work, my plan was so far modified as to make the spinningwork and habits of Orbweavers the principal theme, and to group around the same the industries of other spiders in such relations and proportions as seemed practicable. In the present volume I have adhered to this modified plan, but less closely than in the preceding one, having made large use of the natural history of other tribes than the Orbitelariæ.

It is probable that this volume will be more interesting than Volume I. both to the scientific and general public. It takes up the life history of spiders, and follows them literally from birth to death, from the cradle to the grave; more than that, it goes beyond the sphere of existing faunal life into the geologic periods, and touches upon the history and destiny of ancestral araneads who lived in the strange surroundings of prehistoric continents, the sites of which are embosomed in the rocks, or, like the amber forests, are now beneath the ocean. The courtship and mating of these solitary creatures; their maternal skill, devotion, and self sacrifice; their cocoon life and babyhood; their youth and old age; their means of communion with the world around them; their voyages through the air and dens in the ground; their allies and enemies; their fashion of death and its strange disguises—these and other facts I have tried to bring before the reader in the following pages.

Moreover, my studies have necessarily brought me face to face with many of the interesting problems, theories, and speculations of modern science. I have had no pet theory to approve or oppose, and have not

sought to marshal the facts in hand for or against this or that philosophy of life and its origin. Indeed, my aim has been to write a natural history, and not a philosophy thereof. Yet I have here and there alluded to matters with which current thinking has much to do. This fact may also tend to make this volume more generally interesting than the preceding or succeeding one.

I have not found the difficulties of my task lessened, but rather increased in treating these features of the history. Spiders are solitary and secretive at the best, and these characteristics have reached their highest expression in those acts—cocooning, for example—with which a large part of Volume II. is concerned. It has thus been unusually difficult to secure a continuous authentic record of habits. Then, again, these studies have necessarily been only the recreations of a busy professional life, whose engagements have rapidly multiplied, and been more onerous and exacting in the last six years than ever before. These off labors have, therefore, continually receded or been suspended before the pressing and more serious obligations of duty. Nevertheless, I am glad to have done so much, and have great satisfaction in the hope that others, stimulated by my labors, may pass on through the vestibule where I must stop, and explore the vast temple of aranead lore that lies beyond.

I have spoken of my task as substantially completed. I do not forget that the Third Volume yet remains to be finished, and that it is the most costly, and, in some respects, the most difficult of all. But much of the work thereon is already done, and I feel justified in finishing it in a more leisurely way. That volume, with the exception of two chapters, will be devoted to species work, and will present, as far as it seems to me necessary for identification, descriptions of the Orbweaving fauna of the United States. These will be illustrated by a number of lithographic plates, drawn in the best style of art and colored by hand from Nature. Plate IV. of the five colored plates in the present volume will best illustrate the character of those which are to follow. To the above I will add some species of other tribes whose habits have had especial notice in this work.

I have now said all that I expect to make public of my observations of spider manners, with the exception of one chapter on General Habits, which I have reserved for the opening pages of Volume III., and, perhaps, a second chapter, which may be necessary for the explanation and enlargement of matters to which attention may be called by those who have followed me in the preceding studies.

In these opening chapters of Volume III. I shall consider the toilet habits, manner of drinking, methods of burrowing, moulting and its consequences, prognostication of the weather, some of the superstitions associated with spiders, spider silk and its commercial value, and some other points in the natural history of spiders not embraced in the preceding volumes.

I again make my thankful acknowledgments of the assistance cordially given me by various friends and fellow laborers. Dr. George Marx, of Washington, has been especially helpful by generously placing at my disposal his entire collection of spider cocoons, and also by notes upon the habits of some of the species whose life history I have described. To Prof. Samuel H. Scudder I am indebted for various references and hints in preparing the chapter on Fossil Spiders, and for the use of his own publications. Mrs. Mary Treat and Mrs. Rosa Smith Eigenmann have both helped me with valuable material sent by the one from the Atlantic coast, by the other from the Pacific.

H. C. McC.

THE MANSE,
PHILADELPHIA, July 3d, 1890.

TABLE OF CONTENTS OF VOLUME II.

PART I.—COURTSHIP AND MATING OF SPIDERS.

CHAPTER I.

WOOING AND MATING OF ORBWEAVERS.

CHAPTER II.

COURTSHIP AND PAIRING OF THE TRIBES.

CHAPTER III.

COMPARATIVE VIEWS OF VARIOUS MATING HABITS.

PART II.—MATERNAL INDUSTRY AND INSTINCTS.

CHAPTER IV.

MATERNAL INDUSTRY: COCOONS OF ORBWEAVERS.

CHAPTER V.

GENERAL COCOONING HABITS OF SPIDERS.

CHAPTER VI.

COMPARATIVE COCOONING INDUSTRY.

CHAPTER VII.

MATERNAL INSTINCTS: MOTHERHOOD.

PART III.—EARLY LIFE AND DISTRIBUTION OF SPECIES.

CHAPTER VIII.

COCOON LIFE AND BABYHOOD.

CHAPTER IX.

AERONAUTIC OR BALLOONING HABIT.

PART IV.—SENSES OF SPIDERS AND THEIR RELATIONS TO HABIT.

CHAPTER X.

THE SENSES OF SPIDERS, AND THEIR ORGANS.

CHAPTER XI.

COLOR AND THE COLOR SENSE.

PART V.—HOSTILE AGENTS: THEIR INFLUENCE.

CHAPTER XII.

MIMICRY IN SPIDERS.

LIST OF COLORED PLATES.

CONTENTS OF VOLUME III.

PART I.—GENERAL HABITS AND SUPPLEMENTARY NOTES.

PART II.—DESCRIPTION OF ORBWEAVING SPECIES.

PART III.—COLORED LITHOGRAPHIC PLATES AND EXPLANATIONS.

PART I.—COURTSHIP AND MATING OF SPIDERS.

CHAPTER I.

WOOING AND MATING OF ORBWEAVERS.

I.

There is nothing in the life history of spiders that seems to me more mysterious and wonderful than the faculty by which the male finds the female to fulfill his office in Nature and fertilize the eggs. Over all difficulties and distance, through the midst often of a multitude of individuals of various families and genera, and with apparently unfailing accuracy, the males of the several species find their appropriate mates.

The Mystery of Mating.

It is impossible to determine definitely how wide is the circuit over which is scattered any single brood of spiderlings after its exode from the cocoon. Circumstances may confine all the individuals to a comparatively narrow space. More commonly, perhaps, through the aeronautic habit, by the agency of passing winds, they are dispersed throughout a wide region. Under ordinary circumstances, at least, the space is practically impassible by spiders whose habits are as sedentary as those of Orbweavers. Yet such is the power of the marital sense, and so strong and true the guidance of sexual feeling, that, over all barriers of environment the male reaches his proper consort. As far as I know, he never makes a mistake by falling upon the web of an alien species. At all events, if such error occurs, he knows enough to promptly turn away.

The Male's Search for His Mate.

The partner whom the Orbweaver gallant seeks is commonly seated in a well isolated nest, or at the hub of her snare, separated by a distance of several inches from him as he travels over the leaves, twigs, and other material upon which the foundations of the orb are hung. (See Fig. 1.) The errant lover's difficulty in finding a mate must certainly be increased by this fact, for in his cautious approaches he is not able to draw very near, but must determine through a distance relatively great the question of identity: "Is this a partner of my species or not?" He touches the outer foundation line of the orb, and determines the question from that position. If he is satisfied, he settles near or upon the web, and awaits the issue of his courtship.

And now, how has he determined, simply from contact with the snare spun by his chosen spouse, that this is the individual whom he seeks?

What trace has the female left of her identity? By what subtle influence does she attract her wooer to settle in her vicinity? By what strange responsive power does he know the signs, and discern that his mate and the mating hour are nigh? There is no fact in the life of spiders that has struck me with greater force as an unsolved mystery of Nature than this. I have no suggestions to offer in answer of the queries raised, but proceed to give such facts about the pairing of spiders as have passed under my observation, and been gathered from the records of others.

To arachnologists such studies are of special value. In the systematic grouping of spiders, among the characters to which later students give greatest force are the distinctive organs of the male and female. The characters of the palp on the one, and the epigynum on the other, dominate the decisions by which species are determined. It is certainly reasonable to infer that if the external forms of these organs are of such controlling value in determining species, the use of the organs, or, in other words, the manner of pairing, might be expected to show characteristic differences. In point of fact we so find it; and the reader will be able to determine how closely the one may correspond with the other. I venture to add the suggestion that habits which stand at the very gates of life must have especial value in the natural history of such creatures as we are studying, and no artificial delicacy should turn aside the student.

Males Relatively Fewer.

It seems probable that fewer male spiders than females are hatched from the eggs; or, that fewer reach the adult state. At least, one finds not only in collections, but in field observations, that females commonly greatly outnumber males. It would follow that one male spider probably serves as gallant for several females, a species of polygamy which reminds us of the barnyard chanticleer. This fact, as has been said,[1] would indicate that the peril which an aranead husband is commonly supposed to undergo during courtship has been considerably exaggerated by writers. According to De Geer, in his observation upon Linyphia montana, a single male suffices for many females, to whom he pays his respects consecutively in the same hour.[2] Mr. Campbell saw one male in union with three females of Tegenaria guyonii during twenty days in August.[3] Professor Peckham records similar facts among the Saltigrades. Thorell speaks of the male as "the rarer sex,"[4] and Darwin was informed by Blackwall that males are more numerous than females with a few species, but that the reverse appears to be the case out of several species in six genera. On the other hand, Mr. Campbell captured ten spiderlings of Tegenaria and found that seven of them showed the swollen palps of the immature male.[5]

[1] Emile Blanchard, quoted from Revue des Deux Mondes in "Popular Science," October, 1888. [2] Vide Walck., Aptères, Vol. II., page 411, suppl.

[3] Linn. Soc. Jour. Zool., Vol. XVII., "Pairing of Tegenaria guyonii," page 167.

[4] "On European Spiders," page 205. [5] "Pairing of Teg. guyonii," page 168.

FIG. 1. Snare and nest of the Shamrock spider. The orb, nest, and surroundings show the field of courtship among Epeïroids.

It is perhaps not strange that there should be such wide differences of opinion, since the conclusions are based chiefly upon the indications of collections. Now, in Nature, the males show themselves in greatest numbers at the pairing period. They appear to mature a little earlier than the females, and their solicitations have begun even before there is reasonable hope for favorable response. Thus, at this particular time they may be found by a collector more readily than at any other, and would show in larger numbers in his collection. As most males disappear shortly after maturing, and are probably not long lived, while the female survives until after cocooning, collections made after the mating time would be lacking in males.

Males Before Mating.

FIG. 2. Males of Argiope cophinaria courting the female.

I have seen four males of the Banded and three of the Basket Argiope respectively hanging at the same time upon the margin of one female's snare. I have observed two and three males of the Labyrinth spider waiting in the outer courts of the habitation of the female of that species, and the same number of the Insular spider ranged near the leafy bower of my lady Insularis. I have seen two males of Agalena nævia approaching at one time the door of their lady's silken chamber, although it must be said that one of them promptly ran away when he found that his rival had come nearer than he. It is not unlikely that many females deposit their eggs without previous fertilizing; at all events, I have frequently found cocoons containing infertile eggs. But in the long run, in view of such facts as the above, it is scarcely to be questioned that Nature, who always knows how to hold an even balance in the product of her living creatures, provides a master for every mate.

Several Gallants.

II.

The males of Argiope begin to mature about the middle of July, and they anticipate somewhat the maturity of the female. They may be found

at this period occasionally occupying separate webs, but more frequently domesticated upon the orb of the female, upon which several will be found congregated. For example, in a clump of grasses I found the web of an apparently mature female, to whom three males were paying attention. Two of the males were established upon the outer margins of the female's snare, upon small rudimentary webs. The third had built a separate snare immediately behind the female. There he hung in the usual position at the hub, which was covered with light straggling lines, a kind of imitation of the ordinary shield. Above and below were two faint, irregularly formed ribbons, mere suggestions of the beautiful ribbon spun by the female. This snare had about twenty-one radii and twelve or thirteen spirals beaded apparently in the ordinary way. The web was about four inches in length and about two inches wide.

The Courtship of Argiope.

On the same day several males were found on separate webs. These webs are ordinarily quite rudimentary. In one the upper part consisted principally of a mass of straggling lines somewhat resembling a shield of the female when it is first spun. The lower part had ten radii concentrated upon the hub and all of them crossed by beaded interradials. The occupant hung to the upper part of his snare and stretched his legs over the lower part. The snare in width was little greater than the spider's length measured from the tip of the hind legs to the feet of the fore legs. In other words, he spanned his entire web.

Snare of Male Argiope.

FIG. 3. Male Argiope cophinaria upon his snare.

Another and similar male snare was found spun into the protective wings of a mature female snare. A figure of this rudimentary web is given. (Fig. 3.) On the whole, my observations justify the conclusion that after the male spider matures, the character of his web is rudimentary, after the manner above described and sketched. Previous to that period he appears to form the characteristic web of the species, quite like young females. In the immature state, the male Argiope differs from the mature individual; it then resembles more closely the female in shape and the markings upon its back. Indeed, at first glance, it would be taken for a young female.

In other species the conditions of male spinningwork are different. For example, I found,[1] in a grove of young oak trees, a number of males of Epeira insularis established in nests, and with perfect orbs spread beneath them. The nests were well sewed, and like those of the females, which were numerous in the vicinity. The orbs were also perfect, and of the typical sort. These males were mature; some had their nests built close to those of females, upon whom they were evidently in attendance. In several cases two and three males were seen in the same neighborhood, occupying nests or hanging about the margins of the same female's snare.

Snare and Nest of Male Insularis.

One male of Argiope cophinaria was found on the same day (August 28th), which had spun a tolerably perfect snare twelve inches behind the orb of a mature female. This snare had twenty-eight radii and nine spirals, and the flanks were protected by wings or fenders of the typical sort heretofore described.[2] Thus, there appears to be a striking difference in the character of the web made by the male of this species and that woven by the male Insularis. In Cophinaria the orb is certainly not perfect after the type of the species, but in Insularis it appears in every respect to conform to the type, as does also the leafy nest or tent. It may be added, as perhaps throwing some light upon such a difference, that the male Insularis is a larger and more formidable animal than the male Cophinaria, and relatively much more equal in size and strength to his mate.

III.

The first stages of courtship have already been indicated. Having found the snare of his partner, the male Orbweaver stations himself upon the outer border and awaits results. It is not difficult for him to communicate his presence. Indeed, he must take his place deftly and keep it quietly upon the snare, or he will quickly bring down upon him the voracious lady of the house. A touch of his claw upon a radius would telegraph to the female the fact of his presence; and I believe, from what I have seen of the operations of the male in this preliminary courtship, as well as from the recorded observations of others,[3] that he does thus intimate his presence, and that the first stages of the engagement are consummated by these telegraphic communications back and forth between male and female over the delicate filaments of the silken snare.

First Stages of Courtship.

If matters be favorable, the male draws nearer, usually by short approaches, renewing the signals at the halting places. Sometimes this preliminary stay is brief; sometimes it is greatly prolonged. I have known it to be continued during several days, in which the male would patiently

[1] August 28th, Niantic, Connecticut. [2] Vol. I., chapter vi., page 105, Fig. 96.
[3] See the statements of Walckenaer, Menge, and Emerton, further on.

wait—sometimes, but not always, changing his position—until his advances were favorably received, or were so decidedly repulsed that he was compelled to retire. With Labyrinth spiders I have generally seen the male stationed upon the maze, or that part of the snare which consists of crossed lines. Here he would make for himself, as he hung back downward, a little dome of spinningwork, which spread above him like a miniature umbrella. (Fig. 4.) The male of Argiope cophinaria feels the web with his feet for some time[1] before the final approach. The male of Linyphia marginata, as he cautiously approaches, pulls upon the threads connecting his own with his lady's bower.[2] The male of Epeira diademata commences his courtship by touching with one leg a thread of his lady's web.[3]

Love Signals.

Professor Peckham's observation upon the courtship of Argiope cophinaria is to the same effect. When advancing towards the female, the male seems to pause and pull at the strands of the web, as though to notify her of his approach. When he comes toward her from the front she imparts a slight motion to the web with her legs, which seems to serve as a warning, as he either moves away or drops out of the web. When he comes from behind, she pays no attention to him until he begins to creep up on her body, when she slowly raises one of her long legs and brushes him off.

Argiope's Love Signals.

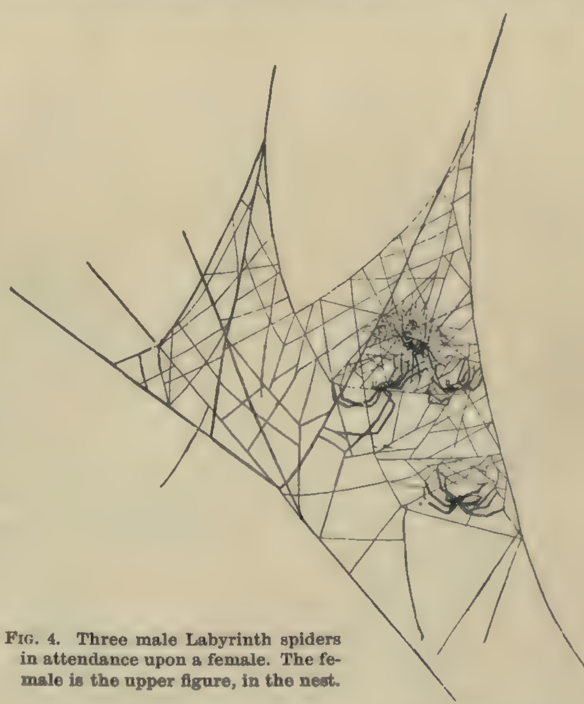


Fig. 4. Three male Labyrinth spiders in attendance upon a female. The female is the upper figure, in the nest.

The same author watched the successive and unsuccessful approaches of three males who were paying their court to a female Argiope argyraspis. The warning vibration of the web as the males approached was noted in this species also, and Professor Peckham believed that the female recognized from the character of the vibration the advent of a male, distinguishing the movement of the lines from that made by a struggling

[1] Emerton, "Habits and Structure," page 87.

[2] See my description of the pairing, hereafter.

[3] Termeyer: Proceedings Essex Institute, Vol. I., page 71.

insect entangled in the meshes of the snare.[1] Of this there can be no doubt, the female appears to be always conscious of the presence of a male of her species, as distinguished from all other intruders.

IV.

The Lover's Peril.

The period of approach or courtship is generally terminated by a sudden rush, which brings the partners into union. The advances, as far as I know, are made by the male; rarely by the female—directly, at least. They are not always received with favor; and it is undoubtedly true that the male is sometimes sorely put to it to make his escape from the premises of an unresponsive female, and occasionally prosecutes his amours at the cost of life. Menge, in the course of his experimental observations, lost many males, after feeding them until mature, by introducing them into a cylinder containing females.[2] Termeyer records, with a "surprise and indignation" which seems refreshing to modern observers, that a male Diadem spider, after the act of union with the female, was attacked by his spouse, and, happening to be in such close quarters that he could not escape, was deliberately enveloped in her threads and devoured.[3]

I have watched this point with great interest in the experimental colonies upon my vines. Many males of Argiope cophinaria have been found trussed up and suspended on the snares of females upon whom I had seen them in attendance but a little while before. Two males were thus destroyed by the same female in one day. In some cases the males would be tolerated for several days, even though they hung quite near, and then, without any apparent reason, would be suddenly found killed and hung up in silken bonds close by my lady's bed at the hub of her orb. In these cases there can be no doubt that the female knew the character of her visitor during all his stay. Any other creature thus intruding would at once have been attacked. The amatory feeling was evidently strong enough to tolerate her lover's presence for several days, but not sufficiently warm to encourage the further advances which he made, and which cost him his life.

One female was attended for a number of days by a male who kept near and just above her, often feeling her gently with his fore legs. I supposed the female to be mature, but could not decide without capturing her. However, I one day found her moulting, apparently the last moult preceding complete maturity. A few hours after the moult I found my patient gallant trussed up and hanging close by his lady love, who had not deigned to eat him. (Fig. 5.) In spider world, at least, it would sometimes seem an ill advised action to "haste to the wedding." I have,

[1] Sexual Selection in Spiders, page 55. [2] Preussische Spinnen.
[3] Proceedings Essex Institute.

FIG. 5. Female Argiope with a fresh moult and slaughtered mate hanging to her web.

but less frequently, noted similar treatment of the male Insularis by his mate. He is better equipped for taking care of himself than the male Cophinaria, but, nevertheless, sometimes pays the penalty of his rashness and importunity.

Males Destroy Females.

Notwithstanding the above facts, I have reason to know that matters are sometimes reversed, and the female is the victim of the cannibal appetite of the male. Among my own specimens, for example, I have had a male of the Furrow spider, which was enclosed in a jar along with two females, satisfy his hunger by devouring one of his partners. Baron Walckenaer saw a male of Epeira inclinata take advantage of a female of his species, which was not able to stir without difficulty, being full of eggs, to attack, garrote, and eat her.[1]

Mr. Campbell observed the male of Tegenaria guyonii destroying the female. Of one pair which he placed together, the male at once began to pay his addresses. Shortly afterward he rapidly applied one of his palps to the female, in the manner elsewhere described, and, apparently, with her consent. Five hours afterward he charged his partner, tore away two legs below the trochanter, and began to suck one, using the mandibles to hold the limb, just as a human being would a stick of asparagus. The female died an hour afterward. This female lacked one moult of being mature; but her killing cannot be explained by her supposed sexual incapability, for Mr. Campbell says he saw two males similarly dismember their spouses an hour after union. Hunger could not have been the cause of this ferocity, for they were well fed. In fact, males in confinement take their food much better than females, which may be due to their being accustomed to feed, during their sexual excursions, in places which are strange to them. Only twice did Mr. Campbell see a female of Tegenaria drive the male away. In both cases this occurred immediately after union. On the other hand, as illustrating the difference which individual disposition or circumstances may produce, the same observer kept together an adult pair of this species from the 22d of August to the 28th of October, more than two months, and they lived in perfect unity. The male never ceased paying unrequited attentions, except to feed.[2]

Relative Size of Sexes.

Excepting one spider, Argyroneta aquatica, whose male is larger than his mate, all those found in Great Britain have the female either equal in size to, or else larger than, the male. (See Figs. 9, 10.) The difference, however, between the sexes in these northern regions is not carried to the extreme limits which are frequently reached in the tropics. For example, Nephila chrysogaster Walck., an almost universally distributed tropical Epeïroid, measures two inches in length of body, while that of the male scarcely exceeds one-tenth of an inch, and is less than one thirteen-hundredth part of her weight. In other

[1] Aptères, I., page 143. [2] Pairing of Tegenaria guyonii, page 168.

FIG. 6. Female and male of Nephila nigra. Natural size. (After Vinson.)

words, the female is twenty times as long and thirteen hundred times as heavy as her partner.[1] Dr. Vinson [2] strikingly represents this disparity of size in the species Nephila nigra (Vinson), which is here presented, (Fig. 6), with both sexes natural size. A full grown female of our Basket Argiope bears about the relative proportion to the size of her male, of a horse to a large dog. The largest female Argiope measures in body length one inch, in spread of legs three inches. Her abdomen is thick in proportion. A male has a body length of one-fourth inch, the spread of legs being one inch and a quarter. Fig. 14 will show the relative body lengths and sizes of the sexes of Argiope cophinaria.

This disproportion, however, in the size of the sexes is not universal. In some species, as will be found by a reference to the plates in Volume III., the difference is slight, and, indeed, is sometimes on the side of the male, even among Orbweavers, as in the case of Epeira strix. Moreover, the males have relatively longer and apparently more powerful legs than the female. The increased length must be serviceable in the preliminary courtship, when the males stand off and solicit or test the feeling of their mates by touches of the fore feet. These features are also beneficial in clasping their mates during amatory embrace, and must add to their muscular vigor both in conflict and retreat. This difference in the legs, I have no doubt, fully compensates for difference in body size in the case of many species. Especially is this true in the case of the Wanderers, with the exception, perhaps, of some of the Thomisoids. Moreover, the legs of some Orbweavers are armed with formidable weapons in rows of strong spines arranged along the inner surface of the tibia. (Fig. 7, Tibial spines of Epeira domiciliorum, a, and Epeira trivittata, b.)

FIG. 7. Tibial spines. (After Emerton.)

Size Variation in Same Species.

There is also a difference in size among the individuals of any one species. I have found females (Epeira vertebrata) quite mature, making cocoons, who were scarcely more than half as large as others of the same species, and to some extent a like difference prevails in the sizes of the other sex. It may readily occur, therefore, that a large male and a small female will come together, and thus, in point of strength, be placed more nearly upon an equality, or even give the preponderance to the male. In such a case his opportunity for feeding upon his partner is quite as good as hers. For these reasons I am disposed to think that the perils of courtship depend, first, upon the relative size of the individuals, and, second, upon the chances of arousing the voracious appetite of one or the other partner by unusual movements. In other and ordinary cases, Nature provides a sentiment

[1] Cambridge, "Spiders of Dorset," introduction, page xxvii.

[2] Spiders of Réunion, Maurice, and Madagascar, Pl. VI.

strong enough to protect the origins of life. It may be added here that the only two species of Orbweavers which are said never to repel the advances of the male are those belonging to the genera Tetragnatha and Pachagnatha—genera, by the way, which are marked by the most formidable developments of the mandibles, particularly in the male, the chief organs of attack and defense among spiders. This would seem to be an example of the theory that the best way to insure peace is to be thoroughly prepared for and formidable in war.

V.

While the above facts represent the relations between the sexes of spiders as they generally exist, there are some exceptions which present our araneads under a more domestic character. Among the Retitelariæ and many families of the Theridioids, the males dwell a long time with the females on the same web. I have frequently observed the male of Theridium tepedariorum, the most ferocious and formidable of our common species, stationed with comparative security upon the cobweb of the female. The interesting little black Lineweaver, known as Steatoda borealis, I have very often found underneath stones, or in webs of crossed lines in other situations, where the two sexes dwelt together in apparent harmony. I believe that this is an habitual domestic characteristic of this species. The pretty Lineweaver, Linyphia costata,[1] also belongs to the few American species known to me of which the male and female occupy a common home. I have nearly always seen them together upon the same slight snare of lines stretched between the edges of a leaf, or in like situations.

More Domestic Habits.

Fig. 8. Male (upper figure) and female of Steatoda borealis.

Dolomedes mirabilis of Europe is said to share with the female the care of their posterity. He will take up the cocoon which the female drops, place it under his breast, and defend it until the little ones are hatched.[2] The males of Epeira apoclisa of Europe are said to dwell with the females in the same nest, without inflicting or receiving injury. According to De Geer the male and female of Epeira fusca dwell harmoniously near each other, at least in the springtime. The male is a little apart from the female, and sometimes ventures to promenade the common web without receiving any injury from his partner.[3] Walckenaer confirms this observation.[4] The little English spider, Ergatis benigna, has earned its pleasant specific name "benigna" by the fact that she lives peaceably with her husband in the same nest. This is

Sexes Living Together.

[1] The Linyphia phrygiana of Europe, according to Emerton.

[2] Walckenaer.

[3] L'Hist. Nat. des Insectes, Tom. 7, page 236.

[4] Apt., Vol. II., page 85.

constructed by the joint labors of the wedded couple, and is a loosely framed den, with quite open meshes, spun upon the blossoming top or between the stalks of grasses.[1]

Of the beautiful European Orbweaver, Epeira quadrata, Menge states that towards the end of July he observed five nests in which the two sexes lived together peacefully. These nests are similar to those made by our Insular and Shamrock spiders, which are dens of folded leaves, whose interiors are tapestried with silk. The female Quadrata occupied the upper part of the nest, having her fore legs doubled up so that the knees projected above the head. The male occupied the opposite part of the tent, and kept his legs folded as conveniently as was possible under the circumstances without elevating the body. This, however, was not a permanent arrangement, but only a preliminary stage of courtship, and doubtless terminated when the act of pairing occurred.[2]

Temporary Residence.

FIG. 9. FIG. 10.

FIG. 9, female, and FIG. 10, male Water spider, Argyroneta aquatica. (After Blackwall.)

I have seen the male and female of our Epeira insularis and trifolium occupying the same tent, apparently under similar circumstances, and regarded the situation as exceptional. Certainly these species habitually live separate.

Domesticity.

The Abbé de Lignac, having placed a large number of Argyronetas in a bottle, found that they devoured each other. The male, says he, which was perhaps the only one, had been sacrificed to the jealousies of the females, who after him were mutually destroyed.[3] Baron Walckenaer records a fact which appears to be contrary to this. He put a number of Water spiders in a glass vase along with some gold fishes. Within the vase he placed a bunch of coral, and observed a female make her bell shaped nest and attach it to a branch of the coral, and a

[1] Staveley, British Spiders, page 120.

[2] Menge, Prussian Spiders. Under Epeira quadrata.

[3] Memoire pour servir à commencer l'Histoire des Araignées Aquatiques, page 52. Paris, 1748. By Joseph Albert de Large de Lignac. I quote here and elsewhere from the original edition in the library Acad. Nat. Sci. of Philadelphia.

large male construct his domicile at the side of this female. He was witness of their caresses and their amours, but having been forced to be absent he could find upon his return only the male and a few young spiders. All the females, to the number of seven or eight, had disappeared. He was not able to recover them, and supposed that they had been devoured by the male, who was in good condition and very lively. However, he never could find any of the débris of the legs and mandibles, and a spider is not able to devour these hard parts.[1]

Clerck kept together one male and ten females of these spiders for many successive days, during which they were not provided with food, without having observed the least disagreement.[2] De Geer placed many males and females in the same vase, and they never attempted to injure each other. He observed that when they encountered one another in the water they mutually felt each other with their legs, embracing with some vigor, and whether male to male or female to female, they opened wide their formidable mandibles with such force that for the moment the observer expected to see them give the death stroke. But they did nothing. After having felt one another for a long time, they separated and swam each to his own cell. De Geer placed water insects into the vessel. The same spiders, who had been so tolerant of one another, instantly seized and devoured these creatures, their natural prey. It seemed to Baron De Geer that the Argyronetas were less cruel than terrestrial spiders.[3]

Agalena.

Cambridge states that the two sexes of Agalena labyrinthea may be found in great amity together in their tubular retreat; so also the sexes of Meta segmentata, Linyphia marginata, and other species inhabit the same web when adult.[4] This statement is made without any qualification, but I am inclined to think, judging from what I know of the American congeners of these species, that the inhabiting of the web by the two sexes is not in any proper sense a dwelling together, but is confined to the period of pairing, when the males seek the web in courtship and remain sometimes hanging about the snare for several days.

Atypus piceus.

Mr. Enoch[5] found on July 7th a male and female of Atypus piceus dwelling together in the same tube, which was a large one. He had no doubt that they had been thus living together since October of the preceding year. If this be so, Atypus presents one of the most striking examples of conjugal domesticity and fidelity thus far observed among aranead tribes. The tubes of the males were generally

[1] Walckenaer, Aptères, Vol. II., page 390.

[2] Svenska Spindlar, etc., page 148. Aranei Svecici, Descriptionibus et Figuris, etc. Caroli Clerck, Reg. Soc. Scient. Upsal Memb. Stockholmiæ, MDCCLVII. In Swedish and Latin. I quote here and elsewhere from the Latin version.

[3] Memoire pour servir l'Histoire des Insectes, par M. le Baron Carles De Geer. Tome Septième, Ouvrage Posthume, page 308. À Stockholm, MDCCLXXVIII.

[4] "Spiders of Dorset," page xxxiii.

[5] Life History of Atypus piceus. Trans. Ento. Soc. London, 1885, page 402.

found near those of the females, and Mr. Enoch believes that they find their way into the female's quarters the same night that they emerge from their own nests.

VI.

Darwin learned from Mr. Blackwall that he had not seen the males of any spider fighting together for the possession of the female. He further expresses the opinion that, judging from analogy, it is not probable that such a habit exists, for the males are generally much smaller than the females, sometimes to an extraordinary degree. Had the males been in the habit of fighting together, Mr. Darwin argues, they would, it is probable, have acquired greater size and strength.[1] But later observers have been more fortunate than Blackwall, and their observations reverse the judgment of Darwin. We now know that, as with many other animals, the mating period of spiders is marked by frequent and vigorous conflicts among the males, who are thus not only exposed to peril from the voracity of their mates, but also from the jealousy of their rivals. It might indeed seem, in view of the fact that a number of males may be found at one time quietly hanging about the lady's bower, that they are not a very combative generation. Doubtless, the males of Sedentary species do have, occasionally, to secure their marital rights by battle. But such combats are probably far less frequent than among the Wanderers. In point of fact, the conditions are such that it is not so easy for them to come in personal contact with one another. When several Orbweavers attend one female they prefer different parts of the web, and even when I have seen them grouped tolerably near one another they showed no disposition to quarrel.

Fights of Males.

With the Wandering tribes the conditions are different and such as to compel personal contact with rivals, and thus it may be that a more combative habit has grown up. This is well illustrated by the observations of Professor and Mrs. Peckham upon the Saltigrades. These naturalists have given a number of interesting and valuable notes upon the combats between males. The various attitudes were both photographed and figured from Nature, and as a result we have not only attractive descriptions but characteristic illustrations. Some of these I have copied. The males of our little Zebra spider, Epiblemum scenicum, which may be seen in the early spring skipping about on walls, fences, and outhouses, were found fighting on a brick wall. They held up the first pair of legs and moved rapidly in front of each other, now advancing and now retreating in a half circle, distant from each other about four and a half inches. There was little real earnestness in the affair, and it

Saltigrade Quarrels.

Epiblemum scenicum.

[1] Descent of Man, Vol. II., chapter ix., page 329, Amer. Ed.

reminded one of the bluster of two boys each threatening and daring the other, and neither willing to be the aggressor. In a few minutes, however, they both wandered away.[1]

Several males of a species of Icius when placed within boxes proved to be very quarrelsome, and had frequent fights, but were never found to be injured. Indeed, after having watched hundreds of similar battles between the males of this and other species, Professor Peckham has reached the conclusion that they are sham affairs, gotten up for the purpose of displaying before the females, who commonly stand by, interested spectators. This harmless nature of the conflicts of spider duelists is in accordance with my own observations, and also in accord with the few statements that have been made by other observers.

Icius. Harmless Duels.

The males of Dendryphantes capitatus are very quarrelsome—sparring whenever they meet, chasing each other about, and sometimes clinching. The Peckhams put eight or ten males into a box, and they fought; and, although it seemed cruel sport, it was soon apparent that they were very prudent little fellows, and were fully conscious that—

Dendryphantes.

> "He who fights and runs away
> Will live to fight another day."

In fact, after two weeks of hard fighting, the observers were unable to discover one wounded warrior. When approaching for combat the males hold the first legs up in a vertical direction. Sometimes they drop the body upon one side, as they jump about each other. These movements are very quick, and they are always ready for a passage at arms.[2]

FIG. 11. Position of two male Saltigrades, Zygoballus bettini, when fighting. (After Peckham.)

Two males of Zygoballus bettini, while executing a dance before a female, engaged in a quarrel. They ran savagely upon each other and fought twenty-two minutes, during one round remaining clinched for six minutes. When fighting, the abdomen is held nearly at a right angle with the cephalothorax. (Fig. 11.) The combatants appeared tired at the close of the battle, but after a short rest were perfectly well and fought a number of times subsequently.[3]

Zygoballus.

Several males and females of Philæus militaris were placed together in a box. Among the males was a large fellow, who proved to be a universal bully. In the course of time another male, almost his size, was

[1] Observations on Sexual Selection in Spiders of the Family Attidæ. Occas. Papers Nat. Hist. Soc. Wis., Vol. I., 1889, page 39.
[2] Peckham, id., page 45. [3] Idem, page 48.

introduced, and he also adopted the role of a bully. After driving his smaller companions about for a time, he was engaged in devouring a gnat, when the original bully emerged from some leaves, got sight of the newcomer, and at once approached, bristling with pride and ire. His first legs were raised high as if to strike, his palps vibrated with excitement, his abdomen dragged first on one side and then on the other. Number Two was evidently of good courage, for he held his ground and, not relinquishing the gnat, raised his legs and clinched with his antagonist. The battle raged for five minutes, and resulted in Number One robbing his antagonist of his dinner and chasing him ignominiously away. For several days following, life in the mating box was robbed of its monotony by perpetual battles among the males. The females, in eluding them, jumped and suspended themselves from threads. On one occasion, the big bully who had now lost his mate, invaded the home of the lesser bully while the owner was out seeking food. The first time this happened the rightful proprietor, upon his return, ejected the invader without ceremony. The second time the two had a prolonged struggle, clinching, and falling thus hooked together a distance of about twelve inches, the height of the box. (Fig. 12.) Some time afterward the two males wandered about, fighting whenever they met.[1]

Philæus militaris.

Fig. 12. Position in battle of two males of Philæus militaris. (After Peckham.)

Pugnacity: Summary

These notes give a brief picture of the general character of the observations made by Professor Peckham. They indicate, first, that the males after maturity, and during the mating season especially, are addicted to frequent quarrels.

Second, their mode of combat consists in thrashing each other with their fore legs, clinching with the mandibles, tugging and dragging each other about, and generally tumbling and scratching one another with their claws.

Third, these conflicts, although they present the appearance of extreme ferocity and deadly purpose, rarely, if ever, result fatally.

Fourth, the females are usually disinterested witnesses of the duels between their attendants, although, in point of fact, the victorious rival receives whatever favors she may have to bestow.

Fifth, the combativeness, or, at least, the actual combats of male spiders are much more frequent between the Wanderers, who, by reason of their errant mode of life, necessarily come into close contact with one another during their rival courtships. The habits of the Sedentary tribes, which keep them stationary at fixed points of the snare, tend to hold the males separate from one another, and thus conduce to peace.

[1] Idem, pages 52, 53.

Combativeness among spiders is not limited to males; the females also fight, and with great ferocity, not only with one another, but with the opposite sex. Professor and Mrs. Peckham have contributed to our knowledge of this trait as displayed by females among the Attidæ, to which brilliant family their studies have been chiefly directed. They found that the females are, with few exceptions, larger, stronger, and much more pugnacious than the males. They placed two females of Phidippus morsitans together in a glass jar. No sooner did they observe each other than both prepared for battle. Eyeing one another with a firm glance, they slowly approached, and in a moment were locked in deadly combat. Within a few seconds the cephalothorax of one was pierced by the fang of the other, and with a convulsive tremor it relaxed its hold and fell dead. In all, four females were placed together, and in each instance the fight was short, but to the death. Subsequently, the observers admitted a well developed male, which, though smaller, was compactly built and apparently strong enough to bring the virago to terms; but, to their surprise, he seemed alarmed and retreated, trying to avoid her; she, however, followed him up, and finally killed him. They observed the same habits in Phidippus rufus.

Female Combativeness.

In Dendryphantes elegans the female is nearly a third larger than the male. A number of this species, males and females, were kept together in a large mating box, and their behavior demonstrated the greater quarrelsomeness of the females; they would frequently go out of their way to chase one another, and they were much more circumspect in approaching each other than were the males. In Icius mitratus neither sex was especially pugnacious, but the male was as little so as the female. In Synageles picata the females never came near each other without some display of hostility, though they did not actually fight. In several species of Xysticus, as ferox and gulosus, the females are savage and ready to attack anything that comes in their way, while the males are smaller and more peaceable.[1]

Quarrelsome Females.

VII.

From these more general facts we may now pass to the detailed descriptions of the act of conjugation in such species as have been studied. I have never been fortunate enough to observe the actual pairing of Orbweavers, my only opportunities of study having been with Linyphia marginata and Agalena nævia. I am therefore dependent upon the observations of others for the pairing habits of the Orbweavers.

Termeyer, nearly a century ago, thus correctly noted some points in the

[1] Observations on Sexual Selection in Spiders of the Family Attidæ, by George W. and Elizabeth G. Peckham, pages 10, 11.

courtship of Epeira diademata: The male approaches little by little with much caution, doubtful of the reception which he is to meet in the web of the female, who occupies the centre, intent only on her prey. He commences by touching with one leg a thread of her web. The female approaches him. He flies, allowing himself to hang by a dropline. Soon he reascends, being assured in some way that he will not be ill received. Then he approaches his mate, and with one of the palps touches her abdomen quickly many times.[1]

Pairing of Diademata.

The pairing of the Diadem spider is also described by Menge.[2] The male accomplishes his approach to the female by means of a strong thread fastened immediately above her, which thread is, in fact, the strongest that he spins. This becomes his love bridge, over which he passes with trembling and uncertainty as to his reception, his feet expressing both invitation and fear. If his reception is friendly, he passes under the body of the female, with his fore feet folded to allow her expanded feet to encircle his, while their faces and partly their breasts touch. He now quickly touches the vulva of the female with his palps, and instantly drops to the ground by a thread; however, he soon returns, and the deposition of the semen is continued until finished. During September, one year, Menge observed a male thus approach a female about twenty times. Finally he caught the ovipositor or hook of the vulva, detaining the same and turning so that the two abdomens and their adjoining parts touched, and the posterior parts of the same were no longer separated, but pressed closely together. The connection continued for over a minute, when the male dropped backwards to the ground, and remained there for some time as if dead.

Menge's Description.

Menge also observed the pairing of Epeira marmorea on a warm August evening. The female left her web and advanced towards the male. The movements of the latter were very careful, and when sufficiently close he touched the vulva of the female in passing, and instantly withdrew. As the female remained quiet and did not attack him, the act was renewed the second and third time. The third time the female retired to her dwelling, and the male dropped down by a thread.

Epeira marmorea.

The pairing of Tetragnatha extensa has been described by several writers. Lister, the pioneer of English arachnology, says that May 25th at sunset he saw the pairing of many spiders of this species. The two sexes were suspended by means of a thread placed upon their webs. The male was below, having his body stretched upon a straight line. The body of the female, on the contrary, was doubled, and her abdomen touched the fore part of the abdomen of the male. He continually thrust a little horn, remarkable by its tubercle, upon

Tetragnatha extensa.

[1] Translation of Prof. Wilder. Proceedings Essex Institute, Vol. V., pages 71–3.

[2] See Prussian Spiders, under Epeira diademata.

the superior part of the abdomen of the female. The feet and mandibles of the one were interlocked with those of the other.[1]

Walckenaer has given a complete and graphic description of the loves of Tetragnatha. His observation was made on the 26th of May, when the weather was serene and moderately warm. A male was stationed under a quite large orbweb spun in an inclined position. The female was below, suspended by the hindermost feet. Her body was bent double, her abdomen in a sense horizontal, so that her cephalothorax was bent back upon the male in a vertical position. Her fore feet were entangled in the fore feet of the male, but gently and without stiffness. Her mandibles were opened, as were also those of the male, and the extremities were supported one upon the other, and presented the form of a trapeze, like the four open blades of two pairs of scissors if joined at their points. The male had his body stretched upon the same line in a horizontal position, but reversed; that is to say, the sternum of the cephalothorax and the venter or lower part of the abdomen were turned towards the sky, and the dorsum or back towards the ground. It resulted from this position that, from beneath, the male, although much smaller than the female, appeared to surpass her in length by half of his abdomen. Further it resulted that the vulva of the female fell exactly beneath the palps of the male. He was suspended from his snare by the fore feet, which were entangled in those of the female. His two hindermost feet were posed upon the abdomen of the female, and served to press her lightly against himself, while he applied the palps to the vulva. The valve of the palpal bulb during the act of pairing was swollen, brilliant, and the color of yellow amber.

Position of Female

Attitude of Male.

This pairing lasted more than a quarter of an hour, and although the observer came very near in order to see more distinctly, the mates did not separate. Once he touched a part of the web and caused it to vibrate. The partners recoiled, but still remained coupled. The female then made some efforts to disengage herself, but the male prevented her. The observer's attention was diverted at this point, for the space of two minutes, to make another observation. When he turned his eyes again upon the pair, only the female remained; she was at the centre of her snare in the accustomed position, that is to say, with the body and feet stretched out. The male had disappeared, and was searched for in vain; but during the search Walckenaer observed another female engaged in spinning her snare while another male waited upon an adjoining branch.

It will be seen from the above account, which describes the entire process, that, making allowance for less skill in observation, the English observer had correctly seen what the French naturalist so correctly reports. Lister, however, represents the male as stretched below the female, while Walckenaer reverses the attitude.

[1] Lister, Historiæ Animalium Angliæ (Araneorum Angliæ), 1678, page 31.

Emerton, in his chapter on the growth of spiders,[1] presents some interesting facts upon pairing. Two of these, the pairing of Linyphia and Agalena, I am able to confirm, from my own observations, as substantially accurate.

Pairing of Argiope.

According to this author, the male of Argiope, which is very small, stands on the upper edge of the web, while the female occupies her usual position in the centre. After feeling the web with his feet for some time, he runs down the centre so lightly as not to disturb the female, and climbs over her body for some minutes in an apparently aimless way. She takes no notice of him at first, but at length, especially if he approach the under side of her abdomen, she turns and snaps at him with her jaws. He is usually nimble enough to dodge and drop out of the web. Not discouraged, however, he climbs up to the top and begins over again. In these encounters the males are often injured. They frequently lose their legs, and one fellow was seen with only four left out of eight, but still maintaining his embrace. At length the male succeeds in getting under his mate and inserts his palpi under her, into the epigynum. (Fig. 13.) In the meanwhile the female hangs in the web, while the male holds by his legs to the under part of her abdomen. (See Fig. 14.[2])

Fig. 13. Male Argiope cophinaria embracing the female. (After Emerton.)

Mr. Emerton thus describes the courtship of Epeira sclopetaria.

Courtship of Epeira sclopetaria.

The approaches of the male were always seen in the evening, just before dark, when the females usually make or repair their webs, and the males are wandering about visiting. The male would climb carefully over the edge of the web, and, finding that the female took no notice of him, would run suddenly towards the middle of the snare, on the side opposite to that occupied by the female. His head was towards her head, and, if she permitted him to approach near enough, he would slap one of his palps upon her epigynum. By this time the female would strike viciously at her lover, and he would drop suddenly out of the web by the usual dragline.[3]

September 24th, on the banks of the river Arduson, Baron Walckenaer found a reed, the leaves of which were spun together into a nest by Epeira apoclisa. He saw the male of this species mounting towards the nest. Wishing to make observations at his leisure, he broke the reed a little below the place where the male stood, and carried the whole to his chamber. The male did not attempt to run away or quit the neighborhood of the nest. Walckenaer placed the reed in a large box. The following morning he saw a long thread stretched and the female issuing from her nest upon

[1] Structure and Habits of Spiders, page 87.
[2] Drawn by Mr. Emerton for this work.
[3] Letter to the author, October 17th, 1888.

FIG. 14. Argiope cophinaria embracing the female. Snare and figures about life size. The male is seen in part just under the abdomen.

the border of the box and in the act of pairing. But the male, forthwith frightened, quitted his hold and ran rapidly away. The female, on the contrary, remained motionless. The observer captured the two and placed them in a covered glass bottle with the nest which the female had temporarily abandoned to meet her partner. He also introduced into the bottle living flies. During three days the mates ceased not to caress each other. The female did not return to her nest, but kept below in a reversed position. The male approached her from the side, with head elevated, stretched out his feet and spread them gently and slowly upon the back of the abdomen of the female, sometimes touching the fore feet with his own by a slight and very quick movement. Then the female leaned to one side, in such a way as to expose her venter, against which the male stretched his palps, and the union took place by means of the palps. It was between 5 and 6 A. M. when this act occurred, and it was repeated many times. During the remainder of the day the couple remained separate. The female rested in the same place almost wholly motionless, without doing anything. The male, more lively, more wandering, more active, constructed a little web, placed himself in the middle and caught some flies. Again, he sometimes promenaded the glass, stretching threads; but always after this momentary absence he returned to a position in front of his spouse, appearing to contemplate her, laid his feet against her own, his head vis-à-vis with her head, in a reversed position.

Pairing of Epeira apoclisa.

Finally the female constructed a tube of silk, within which she retired. The male penetrated this; the tube was large enough to contain the two; and they remained therein for ten days in perfect harmony, without attempting to issue from their love bower. During all this time the female continued to rest wholly tranquil, and did not attempt to escape. It was not so, however, with the male, who frequently wandered abroad into the bottle. The two did not attempt to make orbicular webs, but stretched irregular lines, upon which they caught flies, a fact which shows that spiders are able to adapt themselves and their industry to various circumstances. On the twelfth day, October 4th, the female Apoclisa became invisible, and it was observed that she had returned to her original nest, first built at the top of the reed. The tube was abandoned by her and remained vacant. The male did not attempt to rejoin his companion, but wandered about the glass, occupied in seeking an opportunity to escape therefrom. At this point Baron Walckenaer was compelled to interrupt his observation.[1]

A Love Bower.

I make the following summary of the various stages as above described: First, the female comes out to meet the male; second, she hangs below a few stretched lines, with her back downward; third, the male touches her

[1] Walckenaer, Aptères, Vol. II., pages 63, 64.

back and feet; fourth, the male palpal bulbs are applied many times to the epigynum; fifth, the embrace ceases, the female remains stationary in the same place, the male wanders about, makes a straggling web and catches flies; sixth, the male comes before the female, touches her feet, and remains vis-à-vis; seventh, the female makes a tube and enters it; eighth, the male penetrates the tube; ninth, the pair remain for ten days domiciled within this bower, the female staying persistently within, the male making frequent excursions; tenth, on the twelfth day the female leaves the tubular bower and returns to her leafy nest; eleventh, the male makes no attempt to follow her, but wanders around the bottle, seeking to escape. At this point observation ended, but there was probably nothing further to observe.

Summary of Stages.

Zilla callophylla is lacking in ferocity, and lives on good terms with

Fig. 15. Fig. 16. Fig. 17.
Argyroepeira hortorum. Fig. 15, male; Fig. 16, female; Fig. 17, the male palps, much enlarged. (After Emerton.)

her mate. September 30th a male and female of this species were taken by Walckenaer, and placed in a glass bottle. The male, after the ordinary preliminary caresses, such as touching with the extended feet, stretched some threads in the manner of those which served the female to descend from the top of the bottle to the bottom, where he was. Then, by the movement of her feet, she excited her spouse to approach her. Every part of the male's body trembled in a sensible manner. He advanced towards his mate, not without appearance of fear, since she received him with open mandibles. Three times he essayed, always while advancing, to introduce the genital organ of one of his palps into the vulva of the female, and he succeeded at the fourth attempt with the digital bulb of his left palp. Then was manifest in the male, as in the female, a convulsive trembling of all the limbs and of all parts of the body, which evidently announced that the union was accomplished. Four

Zilla callophylla.

other movements of the same nature, separated only by very short intervals, followed the first. After these five acts of union the male retired to a short distance.

About half a minute afterwards he approached as on the first occasion, introduced the bulb of his right palp into the epigynum of the female; then, after the fifth movement of convulsive trembling, he again retired. He continued in this manner during the space of twenty minutes. In these twenty minutes he made thirteen embraces, or thirteen introductions of the digital bulb of one of his palps into the vulva of his partner. After these acts the male retired and went away. The female rested for about a half hour in the same position, as if she awaited the return of the male, who did not come back. Then she decided to remount to the top of the bottle.[1]

[1] Walckenaer, Apt., Vol. II., pages 71, 72.

CHAPTER II.

COURTSHIP AND PAIRING OF THE TRIBES: LOVE DANCES OF SALTIGRADES.

HAVING thus considered the methods of pairing which prevail among Orbweavers, we may note some of the modes which obtain among representatives of other aranead tribes.

I.

Line-weavers: Linyphia marginata.

On the afternoon of June 14th[1] I witnessed the pairing of a male and female of Linyphia marginata. The spiders were first observed at a quarter before four o'clock. They were hanging inverted in the dome shaped nest of the species, in line with each other and about three-quarters of an inch apart. Each hung within a smaller dome which was formed by the outspread feet drawing down the inner surface of the snare. The nest was hung from the under surface of a plank that jutted over from a pile of lumber, and was about two and a half feet from the ground; so that, seated before the nest, my face was on a level with the spiders.

The male cautiously extended one foot towards the female, and pulled upon the intervening threads. I turned a moment to adjust the block on which I sat, and, on looking again, the two were in embrace. The female was suspended as before, although turned at right angles to her first position. The male's head was laid against the sternum of the female, his abdomen inclined a little upward, the fore legs interlocked with, or, rather, interlaid upon those of the female. Both spiders hung by threads, in the normal way. (Fig. 18.[2]) This was nine minutes before 4 P. M.

After a moment's embrace the pair separated; the female made a circuit of the lower part of the dome, moving in an excited, jerking manner, then returned to the summit. The male approached, the female stretching out her fore legs somewhat as he laid his fore legs within them, which position was maintained, as was the relative position of the two, during the entire period of union. The female, during the act, remained perfectly motionless, except an occasional twitching of the apex of the abdomen.

The two terminal bulbs upon the male palps were laid upon the epigynum of the female, and pressed downward. From one of these issued the

[1] The same species was again seen pairing in August, in Connecticut.

[2] Drawn by Mr. J. H. Emerton for this work.

palpal sac, a bean shaped organ, of a bright amber color, and translucent, which shone brilliantly in the sun that fell full upon it from the west. It remained thus projected for a brief space, held between the finger like tufted horn of the palpal bulb, and was then gradually contracted and withdrawn within the black corneous bulb, which was meanwhile pressed eagerly against the vulva. A small elbow or projection upon the upper part of the bulb seemed to press within the spermatheca. The two bulbs were laid simultaneously upon the epigynum, but the inflated palpal sac appeared in but one bulb at a time, alternately. There was a prolonged squeezing motion of the bulbs, as though

Use of Palpal Bulb.

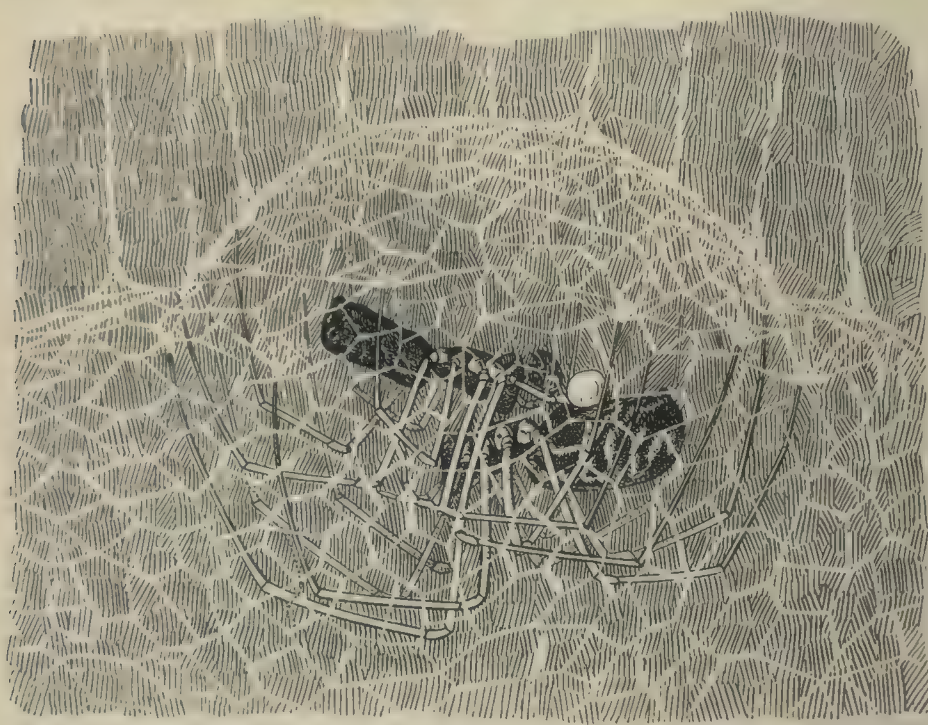


FIG. 18. Pairing of Linyphia marginata. The figures much enlarged. The little dome caused by the pulling down of the feet is represented, and a part of the snare proper.

pressing into the spermatheca, and at times a corresponding motion in the abdomen of the female, especially at the apex. With this exception the female remained motionless during the whole period. After application as above the palpal bulb was slowly, for the most part, but sometimes rapidly raised by the male, bent upward, and apparently clasped upon the falces or lower margin of his face, which parts of course were upward. Three or four movements back and forth in this clinched position followed, when the series of motions above described was repeated.

Biting the Bulbs.

In the meanwhile the second bulb remained upon the other tube until the first bulb began to descend, when it in turn was elevated and the same motion made. As the bulb descended, its sac began to inflate and issue. This process was quite regularly repeated. Sometimes, however, both bulbs were clinched upon the falces at the same time; sometimes the movements of the bulb were more rapid than at others. The bulbs had the appearance of having been moistened by some secretion, presenting the peculiar gloss which a colorless liquid gives to a black surface, but I could see no secretion otherwise, although I was able at any time to use my pocket lens with the exercise of a little care.[1]

Period of Union.

At twenty minutes before six o'clock I was compelled to leave, at which time the pair had been in embrace one hour and forty-nine minutes. At six o'clock twenty-eight minutes I returned, and found the pair in precisely the same positions. I remained five minutes, and then left an intelligent young man at the post, with full instructions as to points of observation. He reported that at thirteen and a half minutes past seven, afternoon, the pair parted suddenly. The male ran down to the lower margin of the dome, pursued by the female, who stopped suddenly just above, and turned back to the central point in the summit. Shortly after receiving this report I visited the web, and found the female suspended motionless in this position, and the male at the point to which he had fled, feeding upon a small fly. The next morning at seven o'clock the female was in the same position, and the male had disappeared. I attempted to capture the female, but she ran among the boards and escaped. The pair had thus been in union two hours and fifty-five and a half minutes.

Interruptions and Separations.

During this period they were separated a number of times. Nineteen of these interruptions were noted; one was caused by a small fly striking the snare, at which the male darted in a fierce manner, but failed to seize, as the fly broke loose before he reached it. Others were caused by the observer touching the foundation threads or other parts of the web. Toward the close of my observations I accidentally broke the suspending lines nearest me, and caused one side of the dome to fall in. This made only a momentary interruption. Many of these separations were, however, apparently without any extraneous cause.

Twice the male ran to one side of the domed snare, made a web attachment to a bit of leaf hanging therein, drew out a thread about two and a half inches long, which he overlaid a couple of times, and then made the following motion: First, the body was placed erect, that is, back upwards, and was moved back and forth along the line, rubbing the points or "nippers" of the palps at the same time; then the spider swung over

[1] I did not at the time suspect that the palpal bulb might have been applied to the abdominal organ of the male, and did not look for this act. But subsequently I have imagined that such might have been the case.

until the body made an angle of about forty-five degrees with the line, and while holding on thus the palps were rubbed back and forth alternately along the line as before. The process was repeated during another of the intermissions, as described above. It was conjectured that the purpose of this movement might have been the distribution of the seminal fluid into the palpal bulbs. It has been supposed that this is taken up by the sacs, by the inflation and contraction of whose membraneous coats it is forced into the spermathecæ of the female.

Steatoda borealis.

Mr. Emerton[1] observed the pairing of the male and female of Steatoda borealis in April, and again in May. The female was in a scant web under a fence cap. The pair stood head to head, as far apart as possible. The left palpus was kept in an hour and a quarter after the couple were first seen. The male contracted his body suddenly, and swelled up the base of the palpal organ once every two or three seconds. Two days afterwards Emerton saw the right palpus used by the same pair for an hour. The adult males and females of this species occur at all seasons, differing in this respect from many others.

II.

Among the Tubeweavers I have observed the pairing of our common Speckled Agalena. The male cautiously approaches over the broad sheeted

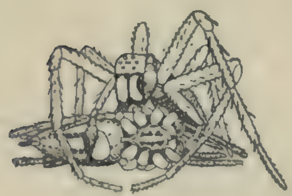


FIG. 19. Agalena nævia pairing. Front view. (After Emerton.)

FIG. 20. Agalena nævia applying the right palp in pairing.

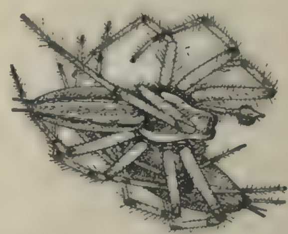


FIG. 21. Agalena applying the left palp in pairing.

Tubeweavers: Agalena.

web which forms a sort of front yard or plaza before the tube in which the female waits. He is usually larger than the female, and is, therefore, better able to compel a respectful reception. In the act of union he takes his partner in his mandibles, turns her upon one side, in which position she lies perfectly motionless, and with her legs somewhat doubled together, as in the attitude of feigning death. (Fig. 19) The male rests upon the side of the female, in a position nearly at right angles with her prostrate body, and, while holding her still with his fore feet, applies the palps alternately to the vulva. (See Figs. 20, 21.)

[1] New England Therididæ, Trans. Acad. Conn., 1882, page 19.

According to Walckenaer, the union of the male and female of the European Agalena labyrinthea takes place in the tube which serves as the dwelling place for the female. In France this act occurs about the middle of July. The female turns herself upon her side, almost upon the broad of her back. The male places himself upon her in such a position as to hide from the observer his head and cephalothorax.[1] It will thus be seen that the method entirely corresponds with that of our own Agalena nævia, which this familiar European spider so closely resembles.

Agalena labyrinthea.

The male of Clubiona constructs a web for union with the female, and prepares, as one may say, the marriage couch, to which he admits the female when the propitious moment has come.[2]

The interesting habits of Argyroneta aquatica, the well known Water spider of Europe, were first fully made known by De Lignac, a priest of the Oratoire, Paris, A. D. 1748.[3] He not only observed the manner of making the nest beneath the water (Fig. 22), which has been frequently confirmed since, but also the act of pairing. When the male wishes to pair, says De Lignac, he constructs near the nest of the female, and by the same means, a nest resembling that of his spouse; but the nest is somewhat smaller. When the male has completed the construction of his domicile, he makes a long canal, which joins his cell to that of his spouse. He then cuts through the wall of the latter, and introduces his body into the strange apartment. This vehicle of communication being made, he strengthens it on the roof and sides. He plasters this, as he does the rest of his nest, with silk, white and impermeable, and thus extends this corridor until it may be as large as the two apartments. Sometimes one sees, but only occasionally, as many as three lodges, which communicate with each other. As these cells have been thus easily united, they also sometimes separate, as, for example, when they are too lightly united, or by the movements of the spiders when they engage in combats, for it appears that during the time of amour they are somewhat irascible. Oftentimes one sees a strange spider making an effort to enter into one of these lodges; but the inmate, who keeps its feet outside, guards, as a watchful sentinel, the safety of its domicile, and drives the intruder from the door.

The Water Spider.

The Lover's Corridor.

Baron Walckenaer confirmed these observations of De Lignac and added some interesting details. On the 27th of July he placed together in glass vessels males and females of Argyroneta. On the following day he saw in one of the silken bells woven by them a male caressing the female with his feet, and carrying his palps to her abdomen. The two spiders were then upon the same line,

Walckenaer's Observations.

[1] Aptères, Vol. II., page 22. [2] Walck., I. Apt., page 143.

[3] L'Histoire des Araignées Aquatiques, page 43. De Geer in Holland as early as 1736 had observed the curious industry of the Water spiders.

and stood face to face. The male carried his head under the body of his mate in a reversed position. He stepped aside, and the female with her feet tickled the apex of his abdomen.

The next day at 6 A. M. he saw a little web constructed by one of his Argyronetas. He gradually filled the bottle with fresh water, whereupon the couple began to work with extraordinary activity, and in less than an hour's time had formed a cell which looked like a bubble of air and had the form of a subterranean vault. The male and female kept together. As soon as the cell was finished, and on the same morning, the female made a web at the surface of the plant which had been introduced into the bell glass. Much to the baron's surprise, she immediately deposited her eggs and enveloped them in a silken cocoon. The cocoon was placed near the surface of the water, and upon the very walls of the vessel. The eggs, which were of a beautiful orange yellow, could be seen through the fine, white tissue of the cocoon.

The Cocoon.

Fig. 22. The subaqueous nest of the Water spider, Argyroneta aquatica, within which the cocoon is woven.

July 29th, at six o'clock morning, Walckenaer saw the female near her eggs; then she ascended to the surface and dived. The male joined himself to his companion. The two spiders gently rubbed the extremities of their anterior feet one against the other, having the air of caressing. Soon this movement of the feet became more brusque and appeared menacing. The male, struck by the feet of the female, suddenly leaped aside, but the pair presently sought each other anew. They interlaced their legs, the one within another, and gradually approached nearer and nearer, head against head. The mandibles were opened; they flung themselves one upon another; afterwards recoiled, separated instantly, and sprang aside as if they had suddenly been seized with fear. Thereupon the female returned to her position near her eggs.

Caressing.

The next day Walckenaer renewed the water in the vessels, and saw the couple approach one another, lightly touch their feet, swim without stretching out any thread and without touching the insects which had been placed in the water for them, but which were all dead. At five o'clock in the evening again the observer saw the male and female upon the cocoon, drawn near together, the feet interlaced and motionless. On opening the bottle they separated. He was then astonished to observe that the web that had surrounded the cocoon had disappeared. Had it been employed to strengthen the cocoon?

Embracing.

The cocoon was a silken flask, attached to a plant by a short pedicle. It was in part immersed within the water. It was rounded, flattened, about three lines in diameter, was formed of a fine thread of a very compact tissue, thin as an onion peel, and difficult to tear. It contained forty eggs, not agglutinated, globular, of a pale yellow color.

The Cocoon.

On the first of April Walckenaer again observed in the jar where the spiders were confined a little bubble of air and a web larger than the former had been. After five days' absence, April 6th he observed that the spiders had detached the cocoon, in order to sink it to the bottom of the bottle. The water was changed in the vessel and immediately they swam about with delight, refreshed themselves, reunited near the cocoon, and caressed each other with their feet. On the 7th of April he decanted the water of the jar into a cistern. The Argyronetas, troubled by the sudden movement of the flood, swam with great rapidity, and the female having recovered her cocoon in the midst of the water, seized it, embraced it with her feet and sought to buoy it up.

One of the most interesting and satisfactory accounts of the act of pairing among Tubeweavers is given by Mr. Campbell from observations on Tegenaria guyonii.[1] The male was placed in a bottle containing a female which had been mature for a fortnight. He was left within the vessel in which he had been lodged, but the cover was removed therefrom. Notwithstanding the glass wall which separated him from the female, he soon became conscious of her presence, and issuing from his own quarters approached her. The following morning he was standing with the first pair of legs over the female, and his maxillæ resting on her abdomen, while she was crouching motionless, with her head in an opposite direction. Both were in the same position the next morning, August 7th, 7 A. M. At 10 A. M. the male became restless, and wandered about the bottle with spinnerets extended, returning every now and then to place his palps upon the female. After each action he jerked his abdomen

Tegenaria guyonii.

Movements of Male.

[1] On the Pairing of Tegenaria guyonii Guer., with a Description of certain Organs in the Abdominal Sexual Region of the Male. By F. Maule Campbell, F. L. S. Linn. Soc. Jour. Zool., Vol. XVI., page 163.

upwards and downwards, a movement which often may be observed in males, and which gives an idea of an expression of impatience.

The next observation, after a few minutes' absence, showed the male about two inches behind the female, standing as it were on tiptoe. His palps were placed alternately and nervously to his maxillæ. On their removal the whole body was raised still higher, and the abdomen brought nearly to a right angle with the cephalothorax, with considerable muscular effort in the basal portion, and with violent tremulations. The movements, which were repeated four times, had the effect of throwing the spider slightly forward, while the palps were shaken in that peculiar manner which denotes great muscular tension in some other part than that in visible motion. The palps were now generally alternately placed under the sternum and moved backward and forward, upward and downward, with a scooping motion. In five minutes these movements of the abdomen and palps were repeated ten times in regular succession, only varied by an occasional transfer of the digital organs to the mouth.

Use of Palps.

Mr. Campbell observed thirteen couples pairing in confinement from the middle of July to the end of August; and the following account may be taken as typical of the species, with the exception that the union does not necessarily occur so quickly after the female has gained maturity. On the 13th of August he placed together a male and female. On the 17th the latter cast her last skin. Up to that time, 6 A. M., they had taken no notice of one another. At 9.45 P. M. the two were so close together that the femora of the first pair of legs of each were almost in contact. After a few convulsive twitches of the legs the male pressed forward, moving his palps up and down, when, as they touched the palps of the female, the pair played with these organs like two friendly bees with their antennæ. After a few minutes the female raised herself, leaning a little on her left side, and the male crept forward until his head was under the sternum of his mate, while his first pair of legs were resting upon hers. He then advanced his right palp, leaning a little to the left, and using the left palp as part of his support.

Approaches.

The male now rapidly raised his palps up and down for four or more seconds, and with such energy as to compel the female to assume a vertical position. He then retired, and again approached her, repeating the movements a greater or less number of times, occasionally pausing before he withdrew his palps with a slight twist inwards. At times he would leave the female for five minutes, and strut with straightened legs around the vase, wagging his abdomen. Now and then he would remain perfectly still with the palp withdrawn, or play with the palps of the female, who seemed in a comatose state. He would then renew the union with undiminished vigor, appearing on each occasion less desirous of changing his position.

Use of Palps.

PLATE I.

COLORS OF EPEIRA TRIFOLIUM.

1–9, VARIATIONS IN COLOR OF FEMALES. 10–11, THE MALE.

[illegible] often may be [illegible] sion of impatience.

[illegible] absence [illegible] as it were [illegible]

[illegible]

PLATE I.

COLORS OF EPEIRA TRIFOLIUM.

1–9, Variations in color of females. 10–11, The male.

The observer left them at 12.30 A. M. and returned at 7 A. M. The male was still using his right palp. He saw no application of the left palp, but had no doubt that it was employed during the night, as in other cases. He had never observed the pairing interrupted for a fresh collection of semen, although there is no reason to think that this may not occur. The duration of the pairing is long, but he was inclined to think it is more dependent on the difficulty in inserting the embolos than on sexual endurance.

Impregnation.

III.

The pairing of Xysticus trivittata Keyserling has been briefly described by Mr. Emerton, and figured.[1] The spiders were seen on the 5th of June among the short grass in an open pasture in New England. The female held herself head downward on a blade of grass, with the abdomen turned away only enough for the male to reach under it with his palps. There did not appear to have been any web on the grass, though there may have been a few threads for the female to hold by.

Pairing of Laterigrades.

FIG. 23. The pairing of the Laterigrade species, Xysticus trivittata. (From Nature.)

Among Lycosids we have the description given by one of the earliest naturalists, Clerck, the Swedish observer.[2] He saw the pairing of Lycosa saccata about the middle of June, upon a rock exposed to the sun. The two sexes approached by jumps, which became fewer and slower as they drew near. The male ended these preliminary stages of courtship by suddenly leaping upon the female. He then passed one of his palps under her abdomen, and, holding and inclining her body with the other, inserted first one and then the other palp. When the pairing was ended, the two sexes separated and promptly ran away from one another.[3]

Pairing of Lycosids.

Emerton [4] says of the same family that the male leaps upon the back of the female, and is carried about by her. He reaches down at the side of her abdomen and inserts his palps into the epigynum underneath. The

[1] Psyche, Vol. V., 1889, page 169.

[2] Clerck, Aran. Svec., pages 91, 92, pl. 4, Tab. 5, Figs. 1, 2, male.

[3] Walck., Apt., I., page 328. [4] Habits and Structure, page 95.

accuracy of the early observation made by Clerck is thus abundantly confirmed. The attitude of Lycosa is represented in Fig. 24, which has been drawn from Nature for this work by Mr. Emerton.

Pairing of Attidæ.

Among the Attidæ, De Geer has described the pairing of Epiblemum scenicum (Attus scenicus), which occurred upon a wall. The male mounted upon the body of the female, passing over her head towards her abdomen, under which he advanced one of his palps. He gently raised the abdomen by upward pressure of his legs, and then applied the extremity of his palp to the vulva. An instant afterward the two spiders separated and removed a little distance from one another. The male did not wait long before again approaching, and he repeated many times the action above described. The female did not offer the slightest opposition, but, on the contrary, seemed to greatly enjoy the act.[1]

IV.

The mating of the Attoïds, as told in the delightful pages of Mr. and Mrs. Peckham's Observations on Sexual Selection in Spiders, presents one of the most important chapters in the life history of araneads. It is a strange and interesting story, a romance of natural history as fascinating as any love story of modern fiction. These accomplished arachnologists, who have carried on all their studies together, have given special attention to the Saltigrades, and they were led into the study of the courtship of these interesting creatures by a desire to solve some of the current problems in natural and sexual selection. Independent of this, the facts recorded are extremely valuable.

FIG. 24. Male of Lycosa saccata embracing the female. From Nature. (Drawn by Emerton.)

Love Dances of the Males.

The first group of observations uncovered the habit of the males to exhibit themselves before the females in a series of varied movements, which may be generally characterized as dancing. The purpose of this appears to be, beyond doubt, to attract the attention of the female, and render her complaisant to the addresses of her lover. The courtship of Saitis pulex was thus conducted: The male, when placed in a box with a mature female, at once observed her, although she was twelve inches away. At the distance of four inches he stood still, and then began the most remarkable performances that an amorous male could offer to an admiring female. She eyed him eagerly, changing her position from time to time, so that he might always be in view. He, in the meantime, extended the fore legs upon one side of the

[1] De Geer, L'Hist. des Insectes, page 90.

body in such wise as to elevate that side and correspondingly to depress the other. The legs and palpus of the lower side were folded under, and upon these the spider sidled along, moving in a semicircle for about two inches. He then instantly reversed the position of the legs, and circled in the opposite direction, gradually approaching nearer and nearer to the female in the course of these oscillations.

Saitis pulex.

The female dashed toward him, while he, raising his first pair of legs, extended them upward and forward, as if to hold her off, but withal slowly retreated. Again he began his oscillating movements until one hundred and eleven circles had been counted. The female in the meanwhile gazed toward him, apparently in a softer mood, evidently admiring the grace of his antics. When he had approached almost within reach of her, he whirled madly around and around her, she joining and whirling with him in a giddy maze. He then fell back, and resumed his semicircular motions, with his body tilted over. She, all excitement, lowered her head and raised her body, so that it was almost vertical. The two then drew nearer. The female moved slowly under the male, he crawling over her head, and the mating was accomplished.[1]

Love Dance of Synagales.

A male of Synagales picata executes his love dance with all his feet on the ground. He raises himself on the tips of the six hindermost legs, but slightly inclines his head downward by bending his front legs, their convex surface being always turned forward. His abdomen is lifted vertically, so that it is at a right angle to the plane of the cephalothorax. In this position he sways from side to side. After a moment he lowers the abdomen, runs a few steps nearer the female, and then tips his body and begins to sway again. Now he turns in one direction, now in another, pausing every few moments to rock from side to side, and to bend his brilliant legs so that she may look full at them. He could not have chosen a better position than the one he took to make a display, and the observers were impressed by the fact that the attitude taken by the males served perfectly to show off their fine points to the female.[2]

Wooing of Marptusa familiaris.

Marptusa familiaris is an Attus of sombre gray and black colors, that may be frequently found on trees, fences, and like positions in the neighborhood of Philadelphia. It is apparently a widely distributed species. When the two sexes were placed together, the female saw the male as he entered at the opposite side of the box, thirteen inches away. Eyeing him attentively, she slowly changed her position to keep him in sight, and kept her palps moving rapidly, a characteristic action of the species. As the male neared her,

[1] Observations on Sexual Selection in Spiders of the Family Attidæ. By George W. and Elizabeth G. Peckham. Occasional Papers of the Natural History Society of Wisconsin, Vol. I., 1889.

[2] Idem, page 43.

he stretched the first and second pairs of legs sidewise, but after a moment backed away. These manœuvres were repeated many times, the attitude assumed during them being as represented by Fig. 25. Occasionally he would bend the tip of the abdomen down, lifting the body up on the last joints of the two hindermost legs. The female always paid the greatest attention to his movements, lying on the ground with all the legs flattened and the palpi slightly raised, the only movement visible being the vibration of the palps. There is a certain slowness and dignity about the wooing of this species, almost ludicrous.[1]

FIG. 25. Positions in courtship of Marptusa familiaris. Male on the right hand. (After Peckham.)

The males of Dendryphantes capitatus approach the female rapidly, until within two to five inches, when they stop and extend the legs directly forward close to the ground, the legs being slightly curved, with the tips turned up. This position serves admirably to expose the whole of the bronze and white face (Fig. 26) to the attentive female, who watches him closely from a little distance. As the wooer grows more excited, he lies down on one side, with his legs still extended. These antics are repeated for a very long time, even for hours, before the female accepts his addresses.

Showing Gaudy Colors.

FIG. 26. Bronze and white face of Dendryphantes. Male. (After Peckham.)

The male of Habrocestum splendens is a magnificent fellow, having an abdomen of glowing pink, and bronze cephalothorax tinted with reddish brown. He began his addresses by advancing a few inches towards the female and then backing off again. This movement was repeated many times. After awhile he settled down under a little web in a corner. The female, troubled by this indifferent treatment, advanced toward him, whereupon he came out and she fell back. This play was kept up for some time, and at length the male began his courting in earnest. When within a few inches of her, he commenced a rapid dance from side to side, raising the whole body high on the tips of the legs, the first pair being directed forward, and the palps clasped together, with the abdomen turned to one side and lifted up. (Fig. 27.)

Habrocestum splendens

FIG. 27. Male Saltigrade, Habrocestum splendens, when approaching female. (After Peckham.)

After a short dance he stood motionless, striking an attitude as shown in the figure, remaining quiet for half a minute. Then he turned his back on the female, moving irregularly about with his legs forward and his palps vibrating.

[1] Idem, page 44.

Again he danced sidewise before her, strutting and showing off like a peacock, whirling around and around. Professor Peckham at first supposed that this turning around was accidental, but it happened so regularly at a certain stage of courtship, that he concluded that it was an important part of his display, serving the better to show his brilliant abdomen.[1]

Color Evolutions.

FIG. 28. Position of male Philæus militaris when approaching the female. (After Peckham.)

Philæus militaris.

In approaching the female the males of Philæus militaris were very eager and fairly quivered with excitement. The first two legs were raised over the head and curved toward each other, so that the tips nearly met, and the palps were moved up and down. (Fig. 28.)[2]

Astia vittata is peculiar in the fact that it has two well marked male forms, which shade into each other, but maintain at least one characteristic distinction, namely, three tufts of hair which mark the black form, niger. Mrs. Peckham was kind enough to send me a box in which were packed a number of specimens of the female and both varieties of the male, in order that I might witness these remarkable courtship dances. This was prior to the receipt of the work from which I have been quoting, and I had but a hint of what I might expect, and how best to proceed. Moreover, my specimens unfortunately, arrived in a bad condition. All were dead except one female and two males, and the latter were much dilapidated, one of them particularly being apparently in a dying condition. I succeeded, however, in resuscitating both males by doses of water and good nursing. One of them in a short time seemed quite well.

Dervish Dance of Astia.

FIG. 29. Male Astia vittata in dancing position before female. (From Nature.)

I placed the three together in a box, and had the privilege of observing, in some degree, what the Peckhams have so fully described. The most lively male at once began animated movements, which were evidently induced by the presence of the female, who, however, ran away and kept circling around the box, running over the walls and climbing upon the glass cover without showing any disposition to respond to the advances made. The male threw himself into what may be described as a rampant position

FIG. 30. The male of Astia vittata in the act of vaulting during a love dance. (From Nature.)

[1] Idem, page 49. [2] Idem, page 51.

(Fig. 29), that is, the body was thrown into a position at about an angle of forty-five degrees, the abdomen almost in the line with the cephalothorax, but a little bent under at the apex, which nearly or quite touched the ground. The two hind pairs of legs were thrown outward from the body, the fourth or hindermost pair being well curved, the third or next pair somewhat bent, but more extended. The second pair (next to the foremost) was quite extended in a line without much curvature, except towards the last two joints. The front legs were extended in a line somewhat curved, and well thrown upward above the head, and the palps, which are black, were stretched out in a corresponding position, and continually rubbed one upon the other in an excited manner. In this attitude the male moved backward and forward with a lively saltigrade movement, whirling around a little as he leaped upward (Fig. 30) and brushing the tips of his palps together in the meanwhile. This was about all I was permitted to see, but it at least confirms in part what the Peckhams have so carefully recorded.

The Peckhams confirmed

FIG. 31. Love dance of Astia vittata. Male with front legs in poise. (After Peckham.)

The first male form, which corresponds in appearance to the female, when he approaches his mate, raises his first legs so that they point either forward or upward, keeping his palps stiffly outstretched, while the tip of his abdomen is bent to the ground. This position he commonly takes when three or four inches away. While he retains this attitude he keeps curving and waving his legs in a very curious manner. Frequently he raises only one of the legs of the first pair, running all the time from side to side. As he draws nearer to the female, he lowers his body to the ground and, dropping his legs also, places the two anterior pairs so that the tips touch in front (Fig. 32), the proximal joints being turned almost at an angle to the body. Now he glides in a semicircle before the female, sometimes advancing, sometimes receding, until at last she accepts his addresses.

Love Dance of Astia.

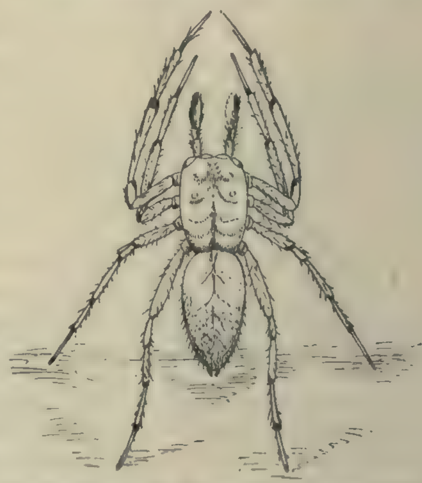


FIG. 32. Position of male Astia vittata when approaching the female. Much enlarged. (After Peckham.)

FIG. 33. Male of Icius mitratus dancing before female. (After Peckham.)

The Niger form is much the more lively of the two, and whenever the

two varieties were seen to compete for the female, the black male was successful. He is bolder in his manners, and was never seen to assume the prone position as did the red form when close to the female. He always held one or both of the first legs high in the air (Fig. 31), waving them wildly to and fro; or, when the female became excited, he stood perfectly motionless before her, sometimes for a whole minute, seeming to fascinate her by the power of his glance.

The male of Icius mitratus is quite different from the female, especially in his slender tapering body and long first legs. The female is remarkable for her indifference, and takes less interest in the male's display of his personal charms than any spider observed. In courting and fighting, the position of the male is the same; the body is somewhat raised; the first legs are held at a right angle to the cephalothorax; the abdomen is twisted to one side, and, as he dances before his lady love, is changed now to the right, now to the left.[1] (Fig. 33.)

It is interesting to find that these amorous displays on the part of males have recently been observed in other invertebrates. Mr. T. H. Morgan thus describes the performance of a male crab (Platyonychus ocellatus) in paying his courtship to the lady crab. The specimens were confined together in an aquarium. While sketching some hermit crabs which had previously been placed in the same tank, the observer was attracted by the movements of the male Platyonychus. Without apparent cause he was seen to rise upon the third and fourth pairs of legs; his large chelæ were thrown above his head, with the claws open and their points touching in the middle line; his fifth pair of feet were held horizontally behind, and his body perpendicular to the floor of the aquarium, or at right angles to the normal position.

Love Dance of the Male Crab.

The posture was ludicrous, and when he began slowly to gyrate, his movements and attitude were the cause of much merriment upon the part of the spectators. At times he balanced on two legs of one side, again on two legs of opposite sides. Now he advanced slowly and majestically, and now he wheeled in circles in the sand on the floor of the aquarium, and now for a few moments he stood as if transfixed in this unnatural position. An electric light hung above and to one side of the water, which suggested the possibility that it might be the exciting cause. It was turned out, and still the dancing went on. At last, from sheer exhaustion, Monsieur Crab sank down to the sand in his usual attitude.

But now the female, who had all this time remained tucked away in the sand, came forth and began to move about the aquarium; soon she came near to the male crab, who instantly rose to his feet and began to dance. Again and again the performance was repeated, and each time the approach of the female was the signal for the male to rear upon his hind feet, and reel about the aquarium as if intoxicated.

[1] Idem, page 50.

At times, when the female approached him as he danced, he was seen to make attempts to enclose her in his great chelate arms, not with any violence, for the claws never snapped or closed violently. She was coy, however, and refused to be won by his advances; for the dance may have been nothing new to the lady crab, nor half as interesting as it was to the two spectators outside the water. Later the male also buried himself in the sand, and the performance came to an end.[1]

Love Dances of Birds.

The love dances of Saltigrade spiders also suggest a similar habit recorded of certain birds. Familiars of our American woods and fields will recall the well known partridge dances. Among the Chatterers the beautiful bird known as the Cock of the Rock (Rupicola rocia) is famous for its saltigrade performances at the mating time. Indeed, the action of our domestic pigeons and barnyard fowls, although not so decided as these, yet suggest a like tendency.[2]

Mr. Wallace has given an account of similar actions by the beautiful Birds of Paradise in the Aru Islands. They moult about January or February; and in May, when in full plumage, the males assemble in the morning to exhibit themselves in a most singular manner. These are what are called their "sácaleli," or dancing parties, and they occur in certain trees in the forest, which are not fruit trees, but have an immense head of spreading branches and large but scattered leaves, giving a clear space for the birds to play and exhibit their plumes. On one of these trees a dozen or twenty full plumaged male birds assemble together, raise up their wings, stretch out their necks, and elevate their exquisite plumes, keeping them in a continual vibration. Between whiles they fly across from branch to branch in great excitement, so that the whole of the tree is filled with waving plumes in every variety of attitude and motion.

Displays of Male Bird of Paradise.

The bird itself is nearly as large as a crow, and is of a rich coffee brown color. The head and neck are a pure straw yellow above, and rich metallic green beneath. The long, plumy tufts of golden orange feathers spring from the sides beneath each wing, and when the bird is in repose are partly concealed by them. At the time of its excitement, however, the wings are raised vertically over the back, the head is bent down and stretched out, and the long plumes are raised up and expanded until they form two magnificent golden fans, striped with deep red at the base, and fading off into the pale brown tint of the finely divided and softly waving points. The whole bird is then overshadowed by them, the crouching body, yellow head, and emerald green throat forming but the foundation and setting to the golden glory which waves above. When seen in this attitude the Bird of Paradise really

[1] T. H. Morgan, Popular Science Monthly, February, 1889, "The Dance of the Lady Crab."

[2] For further material on the display of their charms by the males of birds see Darwin's Descent of Man, Vol. II., chap. xiii., Am. Ed.

deserves its name, and must be ranked as one of the most beautiful and wonderful of living things.[1]

This habit enables the natives to obtain specimens with comparative ease. As soon as they find that the birds have fixed upon a tree on which to assemble, they ambush themselves in the neighborhood. A boy waits at the foot of the tree, and when the birds come at sunrise, and a sufficient number have assembled and have begun to dance, the hunter shoots the bird with a blunt arrow with sufficient force to stun it. It is then secured and killed by the boy without its plumage being injured by a drop of blood. The rest take no notice of the loss, but continue their amatory dance, and fall one after another until some of them take the alarm.

Displays are to Attract Females.

Thus in these widely separated orders of animal life the excitement of the mating hour influences the males in substantially the same manner. That is, the sexual agitation finds vent in saltigrade movements, before and around the female, of various forms and degrees of intensity. These movements appear to be directed towards the female with a view to attract her attention, excite her affection, and win her favors. As far as I can judge, there is no reason why this apparent purpose should not be regarded as the real one, and that these devices, common to spiders, crabs, birds, and doubtless other animals, are really prompted by the wish to secure marital favors from the female, and that they do have a sensible influence upon her.

V.

A Love Bower.

Another interesting habit described by the Peckhams is the overspinning of the female by the male with a little tent or love bower, within which the two remain together, sometimes for several days. Three pairs of the Zebra spider (Epiblemum scenicum) were placed together in a box, and after two hours they had all come to an agreement and mated, the male in each case getting his partner in the corner of the box and spinning a cover over and around her. Sometimes, while the male was working, the female would wander off several inches, but when the bower was nearly completed he would seek her and half lead and half drive her home, when he would follow her into the nest. Here the mating would be accomplished after some slight preliminaries. The female seemed to have some difficulty in choosing from among the males, but after a decision had been reached and a mate accepted, there appeared to be complete agreement, and the male commenced to build his house.

The habit of secluding and protecting the female has developed an even more striking trait in at least one species. The males of Philæus militaris were observed to select immature females, overspin them with a little sheeted tent, then spin a second sheet above this as a cover for

[1] The Malay Archipelago, by Alfred Russel Wallace, pages 466, 467.

themselves, and remain quiet for a week in the little nest thus formed. During this time every spider that approached was driven away. The males went out occasionally for food, but were not seen to carry in any for their mates. At the end of a week one of the males was observed to be pairing with his female, which had moulted and was now mature. Successive observations showed that this marital seclusion of young females was not an accidental result of artificial conditions, but is a fixed habit of the males. It must be acknowledged that it displays a remarkable degree of foresight and thoughtfulness—the immediate product, no doubt, of the emotional conditions of courtship.

Tending Young Females.

In all these various movements the position of the female of most species was simply one of watching. She followed the movements of her dancing partner, evidently with keen interest; sometimes took herself out of the way, but ordinarily was quite attentive until the entire rejection of the suit or the acceptance of the suitor. Two species formed striking exceptions to this rule, as far as the attitude is concerned. In one, the female lay close to the ground with her first legs directed forward and upward, while her second legs were held on the ground and stretched forward in front of her face. In another species, Marptusa familiaris, a similar attitude was assumed by the female, who lay on the ground with all the legs flattened out and the palps slightly raised, the only movement visible being the vibration of the palps. (See Fig. 25.)

The Female Quiescent.

The attitudes of the males were far more varied. A reference to the details of the notes as given will show that at least seven characteristic attitudes are assumed, namely:—

Summary: Attitudes of Males.

First, the legs of one side are bent over, doubled under, and so kept while the male engages in his semicircular dance. (Saitis pulex.)

Second, the body is well elevated, the abdomen lifted vertically, all the legs upraised and stretched out, and the entire eight legs touch the ground during the dance. (Synagales picata.)

Third, the male, like the two females referred to above, lies flat on his venter, keeping the tips of the fore legs touching (Icius); or the male lies flat, wriggling his abdomen and frequently turning from side to side, his legs held up over his head, slightly diverging, and often twisted, waved, or turned about. (Zygoballus bettini.) (See Fig. 34.)

Fig. 34. Position of male Zygoballus bettini approaching female. (After Peckham.)

Fourth, the two front pairs of legs are stretched out in a straight line from the cephalothorax, while the remaining legs are raised and curved and used for moving the body forward in its whirling dance. (Marptusa familiaris.)

Fifth, the first legs are extended directly forward, close to the ground, the legs being slightly curved, with the tips turned up (Dendryphantes capitans), or again he lies down on one side with the legs well extended.

Sixth, the fore legs are elevated high above the head and curved towards each other, while the body is sustained upon the remaining feet during the saltigrade movement (Philæus militaris), or again the fore legs are extended and the abdomen turned up. (Habrocestum splendens.)

Seventh, the spider maintains a rampant attitude, something like the position last mentioned, with the fore feet raised high and curved forward, instead of toward each other. (Astia vittata.)

Position of Male when Mating.

These are the most characteristic positions, and they are maintained during the courtship dance with more or less persistence, according to the various species. The position after the consummation of the wooing is much the same in all species. In mating, the male usually crawls over the female, or the female crawls under the male, and the palps are applied to the vulva while in this attitude. An exception was observed in two species, where the male jumped upon his partner from a distance of one or two inches, the approach being per saltem, instead of by the gradual crawling movement above indicated.

Female Attitude.

For the most part the female appeared to be complaisant or, at the furthest, indifferent. She maintained herself in a position to watch the antics of her lover and to be influenced by them. Sometimes she ran away and avoided the advances of her suitor, but showed no disposition to attack or annoy him.

A Ferocious Female.

At least one exception, however, to this general complaisance was observed in the case of Phidippus rufus, who is a ferocious creature, having a great advantage in size over her partner. It happened to one assiduous male that in an unguarded moment he was pounced upon and eaten up by the lady whom he was wooing. Another species of Phidippus showed the same ferocity. This is our large black Phidippus morsitans, a creature not in good repute in certain parts of the country, it being regarded as one of our poisonous species.[1] The single female which the Peckhams caught during the summer was a savage monster. The two males provided for her had offered her only the merest civilities when she leaped upon them and killed them.

Vain Love Signals.

The male of this species has the first pair of legs much longer than the corresponding legs of the female, and also it is thickly adorned with white hairs, some of which are long and others short and scale like. It was while one of the males was waving these handsome legs over his head that he was seized by his mate and devoured. This love signal was evidently not sufficiently attractive to win

[1] Vol. I., page 276. A letter just received from Prof. Peckham denies this accusation.

the consent of his unæsthetic partner, and, no doubt, had he been less concerned to produce a fine effect upon his lady love, he could have used his legs to better purpose in running away. Nevertheless, the manner in which the snowy legs, as well as the white hairs upon the palps, were displayed before the female's eyes, indicated that he had natural confidence that the lady was to be won in this way, if won at all.

The Peckhams appear to have no doubt that the purpose of this remarkable display on the part of the dancing males is to win the favor of their chosen partners. It seems to them beyond question that, during all these complicated movements, the portions of the body which are most highly decorated are exhibited to the watching female, and are displayed in such wise as to give the most heightened effect to the coloring. It is noted that the portions of the body among Saltigrade spiders which are commonly most highly ornate, are those which are placed at the front of the body, as, for example, the mandibles, which are often of bright metallic colors, green or blue. The arrangement of the hairs upon the face, and also the coloring of the fore legs, appear very commonly to be more attractive than in any other portions of the body.

Color Development.

Indeed, the Peckhams associate the development of this coloring upon the fore parts of the body with the dancing habits which they so attractively describe. They believe it to be the result of sexual selection. In other words, the males which have the brightest colors upon the fore parts of the body are precisely the ones which have survived; since, being more pleasing to the females, they were the partners most frequently chosen, and thus the individuals so marked more frequently transmitted their peculiarities to the offspring. The males will pair as soon as they have the opportunity, and, as the mating season lasts for two or three weeks, the most brilliant males may easily be selected again and again.

CHAPTER III.

COMPARATIVE VIEWS OF VARIOUS MATING HABITS.

From the mating habits of the various tribes of spiders, as described in the preceding chapters, a number of generalizations may be drawn with more or less confidence. These I have thought well to place in a separate chapter, together with several facts connected with reproduction, but not heretofore alluded to.

I.

We may begin by noting the influence of the general habits and characteristics of the various species upon the manner and conditions of mating. Several conclusions and inferences appear.

Generalizations.

First, a marked difference is observed between the methods of the Sedentary and the Wandering groups; and this difference is characterized by the radical difference in their manner of living and capturing prey. The Sedentary spiders carry their persistent habit of dwelling upon the snare into the act of pairing, and the snare is with them constantly the scene of lovemaking. Their courtship and mating proceed while they are hanging to the lines of their snares in the natural attitudes of ordinary life.

On the other hand, with the Wanderers the courtship is in the open, and the male directly places himself upon the body of the female. In this group, also, the power of ordinary habit is seen directing the act of mating, although, of course, in an exactly opposite mode. In other words, species that do not live by webs dispense with webs in mating.

Value of General Habits.

With the Tubeweavers, again, we see the same influence of general habit. This tribe is properly classed with the Sedentary spiders, for they dwell persistently within their webs, by which they capture their prey in large measure. Yet they do not maintain upon their webs, for purposes of feeding, the inverted position that characterizes Orbweavers and Lineweavers. In other words, instead of hanging to their snares head downward, they rest upon their snares in a position entirely similar to that of the ordinary attitude of individuals of the Wandering group, and rush out upon the prey entangled within or near their webs, which they seize and devour, generally without swathing them, as also do the Wanderers. We might, therefore, reasoning from the

influence of general habit, naturally suppose that the method of union would be a compromise between the two already described. So we find it. Among the Tubeweavers the mating occurs within the tube, into which the male penetrates. The bodies come into close contact, and the female remains in a state of absolute quietude.

Second, the differences in mating habit among Sedentary spiders are characterized and evidently modified by the characteristic differences in their snares.

Value of Spinning Habit.

1. With Orbweavers making a vertical web the male approaches from the under side of the female's body, applying the palps in that position, clinging meantime to the female. Sometimes, though probably rarely, the male hangs on the opposite side of the round snare, and from this position applies the palps through the open meshes, or through the free zone, clinging the meantime to the web, as in the case of Epeira sclopetaria.

2. Orbweavers making a horizontal snare, and probably all making composite snares, as Epeira labyrinthea, etc., mate upon the snare, hanging to the crossed lines, back downward; the male above, and face upward; the female beneath, with face upward. In other words, in the case of both these groups of the one tribe the mating occurs while the spiders are in the positions most natural to them during their hours of capturing prey—the one maintaining the vertical position, and the other the horizontal.

Third, the Lineweavers assume precisely the same attitude during courtship that is observed by Orbweavers which make horizontal orbs, and, probably, by those which have a retitelarian annex, like the Labyrinth spider. Here the common habit in the two separated groups has operated to produce a common habit in the act of mating, for the Orbweavers with horizontal snares habitually hang back downward upon their webs, just as do the Lineweavers.

Fourth, in the proportion that spiders come directly in contact with each other during mating without the aid of a snare, does the disparity in size between the two sexes seem to disappear. Among Tubeweavers the male is generally equal, and sometimes superior, in size to the female. The same rule applies to the various genera of the Wandering tribes. The fact of direct contact would seem at once to suggest the necessity of equality in size between the sexes, or a greater degree of complacency on the part of the female. One is not able to speak concerning the latter factor, but certainly the former seems to be reasonably well established.

It is perhaps worth noticing that the greatest disparity in size between the sexes is seen among Orbweavers, and the larger the species, as represented by the female, the smaller does the male become. In the smaller species of Orbweavers the difference between the sexes is not so great, and, indeed, is often scarcely noticeable.

Fifth, amorous solicitations proceed from the male, and as a rule the female is apparently indifferent to, or a passive recipient of, his advances. There are, however, in this respect, differences among the various species, some females being more complaisant than others.

Sixth, the male is frequently less vigorous in physical organization than the female, is generally shorter lived, and is provided, in a less degree, with those habits which secure prolonged activity and greater security. In the matter of spinningwork his acquirements are incomplete or rudimentary with many species; with some, however, this exception does not exist, and the webs spun are as perfect as those of the female. Generally speaking, there is a tendency among males of the Sedentary tribes to defective spinning industry, while among females the habit is invariably complete after their kind. Among the Wanderers, of course, the chief spinning industry is cocoon making and is thus confined to the female.

Seventh, in the case of some species, particularly among the Saltigrades, male spiders have the habit of attracting the notice of the females by certain saltigrade or dancing movements, which appear to be conducted with a view of displaying to better advantage certain attractive colors or markings. This habit is noticeably limited to spiders belonging to the group of Wanderers. In the nature of things it could scarcely exist in the case of Sedentary tribes, since the opportunity to display the person is excluded by reason of the habit which limits their life to snare and nest.

Eighth, in the period of courtship it frequently occurs that several males attend upon one female at the same time. This rivalry is often without any special demonstration of hostility between the attending gallants, but sometimes results in quarrels which, for the most part, appear to be without serious harm to either combatant. The quarrelsomeness of rival males seems to be limited to or greatest in the Wandering tribes, a fact which again probably depends on characteristic habits. Such conflicts are possible with Wanderers, as rival males must come in contact with each other upon the open field in which their loves are prosecuted. But as the amorous movements of Sedentary species must be limited to the snare or nest of the female, opportunities for personal contact are much more circumscribed.

Ninth, as a rule, the general solitary habit of spiders is manifest also in mating habits. With most species there is no such permanent relation of mates as that which one often sees in vertebrate animals. But to this there are some striking exceptions. Certain species seem to have acquired a degree of domesticity, so that the two sexes are quite invariably found together at all seasons after maturity. In a few cases, it has been asserted that the male possesses so strong a domestic character that he will share with the female the care of the egg cocoons, thus approaching the habit of certain birds, fishes, etc., who unite with their partners in providing for and protecting the offspring.

II.

The maternal and sexual instincts exercise a decided influence upon the industrial activity and art of spiders.

Maternity Inspires Insect Architecture.

The influence of the maternal feeling is decidedly manifest in the spinningwork of the female spider. I have often observed that with insects, as ants, wasps, and bees, the habits by which their wonderful architecture is created are prompted by and revolve about the care of the young. It is most manifestly so with solitary insects such as the Carpenter bee and the Mud-dauber wasp, but it is none the less true with such social insects as ants, social wasps, etc. Among these creatures the workers or neuters, as they are popularly called, are undeveloped females, and possess all the instincts of the female of their species. Upon them devolves the work of the colony. They are the nurses of the formicary, as well as its architects, scavengers, soldiers, and purveyors. The whole care of the eggs, larvæ, and pupæ rests with them, and with the greatest enthusiasm and self devotion they exercise that care, venturing their lives freely on all occasions for the welfare of their wards.

Industry Influenced by Maternity

With female spiders a like maternal devotion exists. Their cocooning industry is the most intricate and ingenious of their spinningwork, and this is directly the product of the maternal instinct. How varied, complicated, and ingenious this spinningwork is will be shown in the series of illustrations given in the following chapters. Numerous as they are, they but imperfectly represent the industry of the aranead mother; and I am confident that, when this field shall have been fully explored, my studies will be found to reflect but imperfectly the actual facts as they exist in the aranead world.

It is highly probable that not only the cocooning, but also the nesting, industry is under the influence of the same maternal sentiment. Certainly many of the admirably constructed nests described and figured in Volume I., Chapters XVII. and XVIII., are used as home shelters for the cocoon and the young; as, for example, the nest of our Theridium zelotypum, the wonderful domicile of the English Theridium riparium, and the various subterranean nests of the Lycosids. This would seem to be true also of the remarkable nesting industry of the Tunnelweavers.

Abbé Sauvages expresses the belief that the Trapdoor spider's nest is primarily designed for the preservation of the young, rather than for the preservation of the individuals themselves. Certainly these ingenious structures do serve as a nursery for the spiderlings, as will be shown in Chapter V. The cocoons are suspended within them under the vigilant watch care of the mother, and therein the younglings are hatched and dwell for a considerable period of time. Their habit appears to be to leave the maternal nest only when they are abundantly furnished with strength to enter upon housekeeping for themselves. Then they migrate, and, establishing them-

selves in the neighborhood, pierce the earth with tiny tubes, which in their silk lining and hinged trapdoor are tiny miniatures of the maternal domicile. It certainly is in the line of that influence upon architecture and spinningwork generally, which is associated with, and probably incitive of, the maternal industry, that this remarkable talent for house building should have been developed by the Trapdoor spider. But I am disposed to think that the protection of the spider itself, from certain enemies which are not as yet well known, has much to do with the structure.

Sexual Feeling in Males.

Coming now to the male spider, it may be observed, in certain species at least, that the sexual feeling serves, to some extent, a like purpose with the maternal instinct in exciting the animal to a higher order of industrial art. As a rule, the spinning abilities of male spiders, as far as they relate to the capture of prey, have been shown in Volume I. to be less decided than with females. The rule is not absolute for all species, as in some cases the snare spun by the male is precisely like that woven by the female. But in certain other genera, as, for example, Argiope and probably Nephila, the snares of the male are rudimentary, and do not compare in perfection with those of the female.

Yet, in the hour of courtship, and under the influence of amatory excitement, the male of the Water spider, Argyroneta aquatica, will be incited to weave a silken cell close by that of his lady love, and resort to the unusual device of uniting this with the domicile of his spouse by a silken vault, which is so admirably arranged as to permit communication without inviting destruction in the midst of an element ill calculated to preserve intact a flimsy material like spider's silk.

Influencing Industry.

So, again, it will be found that among the Saltigrades the male of Philæus militaris is prompted by sexual excitement to the remarkable habit of preparing a special silken bower for his chosen mate, to which he leads her, and in which he confines her until the nuptial hour. What is yet more remarkable, the males of this species have acquired the habit of selecting immature females, and secluding them under a silken tent until maturity prepares them for nuptial rites.

It will thus be seen that, under the powerful influence of sexual feeling, the male responds to a higher type of industrial art, and that to some extent this feeling operates upon his organization in the same manner that the maternal instinct influences the habit of the female.

III.

It has been shown that in some species of Orbweavers the females will seize and devour the male even immediately after the exercise of his natural office, which indeed he has to undertake with great self control and care to be able to accomplish it at all. From this propensity of the female,

Rev. O. P. Cambridge[1] accounts for the great lessening in size of some male spiders, as Nephila, in comparison with that of the female, by a kind of sexual selection. It is obvious, he reasons, that the smaller the male the better his chance of escape, and thus selection would operate until males became so small as only just to be able to fulfill the office of impregnating the female.

Disproportionate Size in Sexes.

It is perhaps difficult to reason upon this subject without a much larger array of facts than we at present possess, but there are some points which may be remarked upon with advantage. And it is to be noted that, in the case of Orbweavers, the extremely diminutive size of the male obtains in those species whose females have acquired the largest development. For example, our indigenous Argiopes are among the largest of the tribe, and their partners are very small, not exceeding one-fourth the female's size. The same is true of Nephila wilderi of our Southern seaboard, and in the case of the large Nephilas of tropical countries, as, for example, the Nephila nigra of Vinson (see Fig. 6, page 27), the difference is even more remarkable. Now, it is certainly true that, were the male of a size corresponding with the female, his weight upon the orbicular snare of the genus would appear at first sight to be a disadvantage in several respects. First, it might break down and injure the snare, and thus place a serious obstruction in the way of natural union.

Disadvantages of Large Size.

Again, the advent of such a bulky creature upon the snare would at once advise the female of invasion by a most formidable stranger, and the natural instincts of the occupant of the web would be to regard that stranger as hostile, so that her natural ferocity would be awakened, and the chances for combat and loss of life, or the prevention of sexual union, would be a pretty certain result. From this view of the subject, Mr. Cambridge's suggestion, that the diminution of size would be a great advantage to the male of these large species in accomplishing his amatory purpose and protecting his life, has somewhat to support it.

But, on the other hand, it may be said that the immense snares of Nephila and Argiope are no more fragile in proportion than those of smaller sized Orbweavers, in whose case the sexual disparity does not exist. Again, it might well be reasoned that natural selection might have operated quite as favorably by maintaining the proportionate size of the male or even preserving the largest examples of that sex, inasmuch as increased strength would make him more formidable and thus better fitted to accomplish his purpose. In other words, there is no reason why Nature should not have preserved or bestowed the advantage of superior strength, as well as the advantage of insignificance in size and therewith, perhaps, corresponding caution and ingenuity in approach. As

Per Contra.

[1] Zoologist, 1868, page 216, and Proceedings Zool. Soc. Lond., 1871, page 621.

to the latter point, however, I must say, as a result of many observations, that I have not been at all impressed with the ingenuity of the male sex of Argiope in approaching his lady's premises. On the other hand, I have rather acquired the impression that he shows a remarkable degree of stupidity or, at least, stolidity.

Natural Selection.

Moreover, Mr. Cambridge's argument implies the fact that at one time the sexes were of equal size, and that natural selection operated in the way of producing a diminution of size in the male, to his advantage. But this hypothesis, in its first particular, is not admissible, by the very nature of the reasoning, which implies the necessity for a reduction in size in order to preserve the male, and thus facilitate the preservation of the species. It seems difficult to convince one that Nature, having at the outset provided a comparative equality between the species, or wrought the sexes up to such an equality, should have felt compelled to reverse her decision and her processes, and reduce the size of one of the sexes to such ridiculously small proportions. In other words, if Mr. Cambridge's theory starts out, as it seems to do, with a comparative equality of the sexes, there appears to be no reason why that equality, having once obtained, should not have continued; for the fact that it had once obtained forbids the hypothesis that any necessity existed, or would be likely to arise, for reducing the original equality of size.

Sexes of Equal Size.

Still further, it is a very common thing to find Orbweaving species whose sexes are of nearly equal size and vigor. Such, for example, are Epeira strix, Epeira sclopetaria, and Epeira labyrinthea, which are among our most common indigenous species. The same is true of many Lineweavers, as, for example, Theridium tepidariorum, Steatoda borealis, Linyphia marginata, and Linyphia communis. The reasons for difference in size between the two sexes would seem to be equally potent in the case of the above species, and all others of like habit. Yet we see that natural selection has not operated along the line of action supposed in the case of Nephila and Argiope. Certainly these exceptions are too numerous not to be regarded as throwing much discredit upon the theory or, at least, laying upon its supporters the burden of further proof.

Nesting Species.

It is pertinent to ask, do those Orbweaving species which habitually occupy nests or tents, in which the pairing occurs, at least occasionally, show a disproportion of size on the part of the sexes? One would reason that in such cases a substantial equality of size, or even the superior strength of the male, would work to his advantage, and so to the propagation of the species. That is to say, it has been found that among the Tubeweavers and Wanderers, and all other species where courtship and mating are conducted by direct contact, and not by the act of suspension within the snare, as is habitual with Lineweavers and Orbweavers, the male is of equal, or even superior, size. In the case

of the nesting species of Orbweavers does the same rule obtain, thus following the line of similar mating habit?

With Epeira trifolium the males observed by me are very much smaller than the females. The disproportion is nearly as great as between the male and female of Argiope. In the case of Epeira insularis the male is smaller than the female, but the disproportion is not great. The male of Epeira domiciliorum is not greatly inferior to the female. The male of Epeira cinerea is smaller in abdomen, but in the size of the cephalothorax and mouth parts is about equal, and the legs, if anything, are more powerful. So far as our American species throw light upon the question, it would seem that the Orbweavers who persistently dwell within tents, show no very marked disparity of size between the sexes. This is the rule, with occasional exceptions. Among British spiders, as described by Blackwall, the case is as follows: In Epeira quadrata the male is about one-half the size of the female; the female of Epeira apoclisa is about one-third longer than the male.[1] The proportions are nearly the same as those prevailing between the sexes of American nesting species; but there is apparently a greater tendency in the former than the latter toward diminished size of the males. On the whole, it can hardly be inferred that the facts among Orbweavers indicate that equality of size results from contact of male with female without the mediation of a snare.

No Marked Disparity

It has already been intimated that, ordinarily, where the sexes habitually come into direct contact, by reason of their natural habit, the disparity in size between them is less noticeable. Even among species of the Sedentary tribes, such as the Tubeweavers, where union does not occur during suspension upon the web, this rule obtains. For example, the male of Agalena nævia is quite as large and powerful as the female. In the case of the remarkable Water spider of Europe, Argyroneta aquatica, the male is even larger than the female. There is, perhaps, some relation between this fact and the necessity which seems to be compelled by the element in which the life of the species is spent, and which appears to preclude anything like cautious approach. The male Argyroneta must necessarily adopt for his motto the Virgilian sentiment "Fit via vi" in his approach to his lady's domicile. It thus falls out that the superiority of size proves to be a considerable advantage to him.

Sexual Size in Tubeweavers.

Among Tubeweavers, generally, there exists no very marked disparity of size. With the immense creatures popularly known as Tarantula, the Mygalidæ, the male is certainly somewhat smaller than the female, but the difference is not sufficient, as far as my observation extends, to make any great disproportion in vigor. In fact, in this and in all other cases, it

[1] Spi. Gt. Brit. and Ir., plate xxii., Figs. 236, 237.

must be remembered that the abdomen of the male is always, and necessarily, by reason of difference in organization, much smaller than that of the female, which gives him, to the current observer, the appearance of being less in general size. But the organs of offense and defense are not situated in the abdomen. The legs and mouth parts of the male, including the cephalothorax, are often equal or superior in size to those of the female, even when he seems at a casual glance to be much smaller by reason of difference in size of the abdomen.

Male Anatomy

Among the Wandering tribes the same rule holds good. The Attoïds show a substantial equality in size between the two sexes, there being an average difference of about one-sixth in favor of the female. But this difference in size does not necessarily imply a difference in physical vigor. It must also be remembered that at the mating period the sexual excitement of the male imparts an abnormal degree of strength, which helps greatly to overcome any disparity in physical organism which may exist. The Lycosids follow the same rule of substantial equality in size, with a slight difference in favor of the female.

Wanderers.

In the case of the Laterigrades the rule holds good, as an examination of the superb plates of Blackwall's "British Spiders" (Plates IV and V), will show. There are some remarkable exceptions, for which I am not able to account. With a few Thomisoïds there is said to exist the same immense disparity in size that has already been noted between the sexes of the Orbweaving Nephila and Argiope.[1]

IV.

The numerical proportion of the two sexes is a matter of great interest, not only in itself, but in its bearing upon certain theories, especially relating to development. The facts are so insufficient, and at many points so conflicting, that it is a difficult matter to arrive at anything like a settled conclusion.

Numerical Proportion of Sexes.

M. Eugene Simon remarks that in the genera where the inequality between the sexes is slightest the number of males appears to be equal to that of the females, since at the period of amour Orbweavers having this characteristic regularly come together in pairs. But in the genera where there is a great disproportion of size the number of males is much more considerable, since it is not unusual to see four or five individuals of the sex courting one female. These little males mature first, but the duration of their life appears very short, for after the period of reproduction they completely disappear. They do not construct a proper web, but keep in the neighborhood of those woven by the female, watching for the propitious moment for union.[2]

[1] Cambridge, Art. Arachnida, Brit. Encyc.

[2] Les Arachnides de France, I., page 20.

Blackwall and Mr. C. Spense Bate reported to Darwin that the males of spiders are very active and more erratic in their habits than those of females.[1] This appears to be a general opinion among araneologists, upon what ground as to the matter of activity I am not able to perceive. One, of course, is compelled to ask what is meant by activity and inactivity as applied to spiders. Certainly the words must be regarded as relative terms. There is a sense in which the females of Sedentary spiders are not as active as the females of the Wandering groups. They may not, indeed, be able to make way over the ground and among herbage with the same facility that marks the Saltigrades, Laterigrades, and Citigrades; but the activity in spinningwork of the average female Orbweaver is simply enormous. One who has watched the method by which the great round webs of our common indigenous species are spun, will certainly agree that the operator is one of the most active of creatures in that department of work, at least. The rapidity with which the threads are woven, the unceasing play of the hind legs in pulling out the thread, and the striding of the other limbs around the circle, together with the active exercise of the remaining organs, are evidences of immense vigor and activity. The fact that such a large and intricate web as Epeira spins can be wrought out in the course of half an hour or forty minutes, is proof enough of this activity. These snares will be reproduced several times a day if necessary, and the reproduction continues day after day throughout the lifetime of the aranead.

Are Males the More Active Sex?

Female Orbweavers' Activity.

So also the same vitality of the female Orbweaver appears in the construction of nests, which is not an inconsiderable work, involving no slight exercise of strength, as well as of ingenuity, as any one will see by turning to the chapter upon Nesting Habits, of this work, Chapter XVII., Volume I.

Again, this activity appears in the capture of prey. If any one will take his stand before an average orbweb of almost any common species, say Epeira strix or Epeira sclopetaria, or Argiope cophinaria, at a season when flies and other insects abound, and in a site where they are plenty, he will be surprised at the intense activity displayed in the capture of insects. One after another these victims are seized, swathed, dragged to the hub or den to be devoured, and that with a display of vigor in capturing, in swathing, in cutting out the captive, and repairing the web, which must strike the most casual observer. The feast will be left a number of times to seize and truss up in like manner other victims who happen to strike the snare, and on each successive capture the same tremendous rush and energy of action will be noticed.

Activity in Capturing Prey.

[1] Descent of Man, chapter ix., Vol. II., page 329.

I scarcely know a limit to the voracity of these orbweaving spiders when full opportunity is given them to feed upon their natural prey; and I can certainly appeal to any one who has observed the actions referred to, whether the whole demeanor of the aranead is not such as to impress him with the sense of a vast store of vitality, and an almost exhaustless activity. Taking, then, the spinning-work and the ordinary action in capturing prey by means of nets as the standard, it cannot be affirmed with truthfulness that female Orbweavers are inactive, or that they suffer in respect of this element from comparison either with the Wandering tribes or with the males of their own species.

Female Activity.

I might go further and say that when a female Orbweaver is placed upon the leaves of a plant, or even upon the ground among the grasses, she will display an amount of activity in getting from leaf to leaf, and limb to limb, and from point to point, which is surprising in a creature whose habits are so generally sedentary. I have often been amazed at the rapidity and facility with which the largest Orbweavers, as Argiope cophinaria and argyraspis, could make the circuit of a bush, or travel over a plane surface.

As to the males of Orbweavers generally, it is certainly not in accordance with my observations that they are more active than the females. On the contrary, I am disposed to think them rather lethargic and sluggish fellows. I am aware that it has been said, in corroboration of the theory that the female is more inactive than the male, that she will hang to the hub of her orb, or remain motionless within her tent for hours and perhaps even days. It is true; but that action is quite as characteristic of the male as of the female. I have seen the males of Cophinaria, in attendance upon a female, hanging upon the outer courts of their lady love's snare, apparently entirely inactive, for as much as two or three or four days in succession. They are very patient in their waiting, and make few movements during the courting period.

Male Sluggishness.

So also it may be said that those Orbweaver males which spin webs that are as perfect after their kind as those of the female, show precisely the same degree of patience in managing their snares and watching for the advent of insects, as is shown by the female.

If we turn now to the Wandering groups, and make comparison between the males and females of the species of these tribes, I am certain that it will be found that the females are as active as, or even more active than, the males. During certain seasons of the year, as, for example, when they are carrying their cocoons, they do indeed prepare for themselves a little cave or silken cell wherein they live until their young are hatched. But during that period, even, the Lycosids may be found running around upon the rocks and over the fields, dragging their egg bag after them. When

Wandering Groups Compared.

the young are hatched, it is not uncommon to observe the mother wandering over the fields with all her offspring piled upon her abdomen and the lower part of the cephalothorax—a strange, and, to most beholders, a horrible sight, since the ordinary observer is not apt to associate the uncouth vision with the beautiful maternal devotion which the spider thus shows, and which has its analogue in the human mother bearing her child in her arms, or carrying it upon her bosom. Moreover, the excavating and fitting up these subterranean homes is a strong proof of a decidedly industrious character, and the act requires the exercise of great vigor, which, of course, is exclusively by the female.

As a matter of fact, therefore, I am compelled to think that among all Wandering groups the difference between the activity of male and female is certainly not in favor of the former. Whatever conclusions, therefore, are drawn from the belief that the male is possessed of greater activity and vital force than the female, must, in my judgment, be regarded as erroneous. That he is more erratic, in certain species, is true.

V.

There appears to be little doubt that previous to the act of pairing, the fertilizing fluid is extruded from the sexual organs of the male upon particles of spinningwork, thence is transferred to the digital joint of the male palps (Figs. 35 and 36), whence it is conveyed to the epigynum of the female. The alternate inflation and contraction of the palpal bulb is probably the means by which the fertilizing fluid is forced into its proper receptacle. Various naturalists have been able to establish this fact. Menge has observed, in the cases of Linyphia, Agalena, and Lycosa, this fluid collected from the sheet like spinningwork.[1]

Conveying Spermatozoa.

Digital joints of males. FIG. 35 (upper). Epeira trivittata. FIG. 36. Epeira domiciliorum, largely magnified. (After Emerton.)

Mr. Campbell, in the case of Tegenaria guyonii above cited, was able to confirm this account. It was only during the last moments of the process that reflected light permitted him to see a triangular silken sheet attached to the spider behind the abdominal sexual organ by its apex, and by its external angles to the mesh across the bottle in which the aranead was confined. The sheet extended from under the abdomen to the anterior part of the sternum, and lay above the palps. The male now left the sheet and approached the female; but she appeared heedless of his addresses. The observer seized him, and in his attempts to evade capture he injured the silken sheet. An examination

[1] Preussische Spinnen.

showed that the sides consisted of many shreds (Fig. 37, A), while the intervening space was covered with an irregular mesh, which was doubtless originally more systematically arranged. Here and there was a mass of semen containing a fine, granulated substance (Fig. 37, B) of great refractive power. The whole was in a very liquid state, and spermatozoa were arranged singly above the threads.

Immediately after the spider was secured, one of its palps was removed. The vesiculum seminis was charged with spermatozoa, even to the embolos, where they were plainly seen at intervals. He could not, however, discover any on the external parts of the palpus. Menge is entitled to the credit of discovering the relation between the male palpus and the male abdominal sexual organ.[1]

Ausserer confirmed the observations of Menge in studies of Linyphia triangularis and Dictyna benigna.[2] Bertkau, following the same line of investigation with Linyphia montana and another species, corroborated these statements.[3]

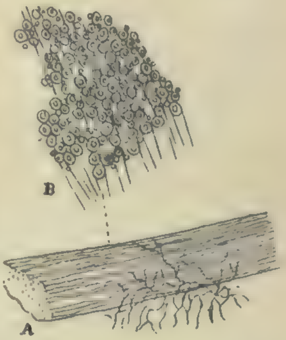


FIG. 37. Spermatozoa of Tegenaria. × 570. (After Campbell.)

Applications of Palps.

In the act of copulation Blackwall observed, what I have recorded of Linyphia marginata, that the palps were frequently conveyed to the mouth. He saw a male Lycosa lugubrius apply his palps eighty times to the vulva of the female without the possibility of bringing it into contact with the inferior surface of its abdomen, except by a very conspicuous change of position. As an equal number of similar acts was performed by the left palp, we have the extraordinary fact of the palps being employed one hundred and sixty times during this greatly protracted process, unaccompanied by any contact whatever with the part where the seminal ducts are considered to terminate.[4]

VI.

Agamic Reproduction.

Whether or not spiders may be propagated by agamic reproduction is an open question. I am at least satisfied that females will produce cocoons without previous pairing with the male. It is reasonably certain, also, that in some species a single act of fecundation suffices for all the eggs laid for several years in succession, where life is continued that long. Audebert brought up and kept for some years many individuals of the domestic spider, probably Tegenaria domestica.

[1] "Ueber die Lebensweise der Arachniden," Neuste Schriften der Naturf. Gesellsch. Danzig, Vol. IV., 1843.

[2] "Beobachtungen über die Lebensweise, Fortpflanzung und Entwicklung der Spinnen," Zeistchr. Ferdinandeums, 1867.

[3] "Ueber den Generationsapparat der Arachniden," Arch. Nat. Gesch., 1875, page 254.

[4] Zoolog. Researches, page 315.

Some females which had been isolated, produced in succession several generations, each in its order being equally fruitful.[1]

Mr. F. Maule Campbell records an example of probable parthenogenesis in the common English house spider. An immature female of Tegenaria guyonii was taken and boxed in May. It moulted twice, and survived during the winter confined within a large glass bottle. Herein she quite domesticated herself, and was fed throughout the winter. In the early part of April she spun the ordinary cocoon of her species, within which she deposited eggs, and about a month thereafter she died. On the 7th of June, Mr. Campbell, observing some movement in the cocoon, separated the sheets enclosing the eggs and found that two spiders had been hatched. Twelve eggs still retained vitality, while the rest were hard and shriveled. The fertility of this spider, after a confinement of eleven months, during which time she twice moulted, can only be explained by one of the following alternate causes: First, that she was impregnated previous to the casting of the two exuviæ in an early, and therefore immature, stage; second, that parthenogenesis occurs in true spiders.[2]

Mr. Campbell is inclined to believe that the case recorded by him is one of agamic reproduction, inasmuch as he could find no lumen in the exuviæ through which impregnation could have taken place. This is justified by the opinion of Bertkau, which expresses the general belief of araneologists: this much is certain, that spiders immediately upon or shortly after the final moult become sexually mature.[3]

---

[1] Cuvier, Animal Kingdom, Lond. Ed., Vol. XIII., page 468, supplement.

[2] Jour. Linn. Soc. Zool., Vol. XVI., page 538.

[3] "Ueber den Generationsapparat der Araneiden," page 253.

PART II.—MATERNAL INDUSTRY AND INSTINCTS.

CHAPTER IV.

MATERNAL INDUSTRY: COCOONS OF ORBWEAVERS.

The maternal industry of spiders is concerned chiefly in the preparation of the silken sac within which the eggs are deposited. It includes also the various methods by which this sac, when woven, is disposed of in order to secure a greater protection for its contents from exigencies of climate and weather, and assaults of enemies. I shall treat this part of my subject after the methods previously adopted, and describe in detail the cocooning habits of Orbweavers, and then present brief studies of the cocoonery of typical species of other tribes, with a view to comparison as to various points, such as the form, number, modes of preservation, and construction.

I.

Among Orbweavers, the largest cocoon known to me is that of Basket Argiope. It is usually a pyriform or globular flask or sac of stiff, parchment like, yellowish silk, suspended in various sites by a series of short lines passing from all parts thereof to surrounding objects. These lines, at the points of attachment to the cocoon, diverge into minute conical or pyramidal deltas, similar to those formed to anchor the usual dragline when the spider walks.

Argiope's Cocoons.

The objects upon which the cocoons are hung depend, of course, upon the local habitat of the individual. For the most part, Argiope spins her web in low positions; on the tall grasses growing in the angles of a rail or "worm" fence; on the miscellaneous shrubbery that will be seen along the edge of a New England stone fence; in the low bushes of various sorts found in fields, lanes, the skirts of woods, and out of the way places—one will be sure to meet these pear shaped objects in October or early November.

A collection that lies before me as I write will be sufficiently typical of the positions in which Argiope spins her cocoons. Here is a cluster of tall grasses, upon which two cocoons are hung. One, with a brown external case, is suspended within a series of closely intersecting yellowish threads, which are lashed to the stalks of the grass eight inches from the roots. Just within the little concavity formed by the stems as they have been pulled together in a circular position, the little

Cocooning Sites.

flask, with its precious contents, is swung. At the top of this clump a second cocoon is placed. It is of a yellowish white color, and, in order to give it a proper site, the tops of the spears of grass have been pulled down and twisted together, so that the capsules, or graceful clusters of seed vessels, hang around the cocoon on every side, giving it a beautiful setting. These cocoons are eleven inches apart, and were probably spun by two spiders.

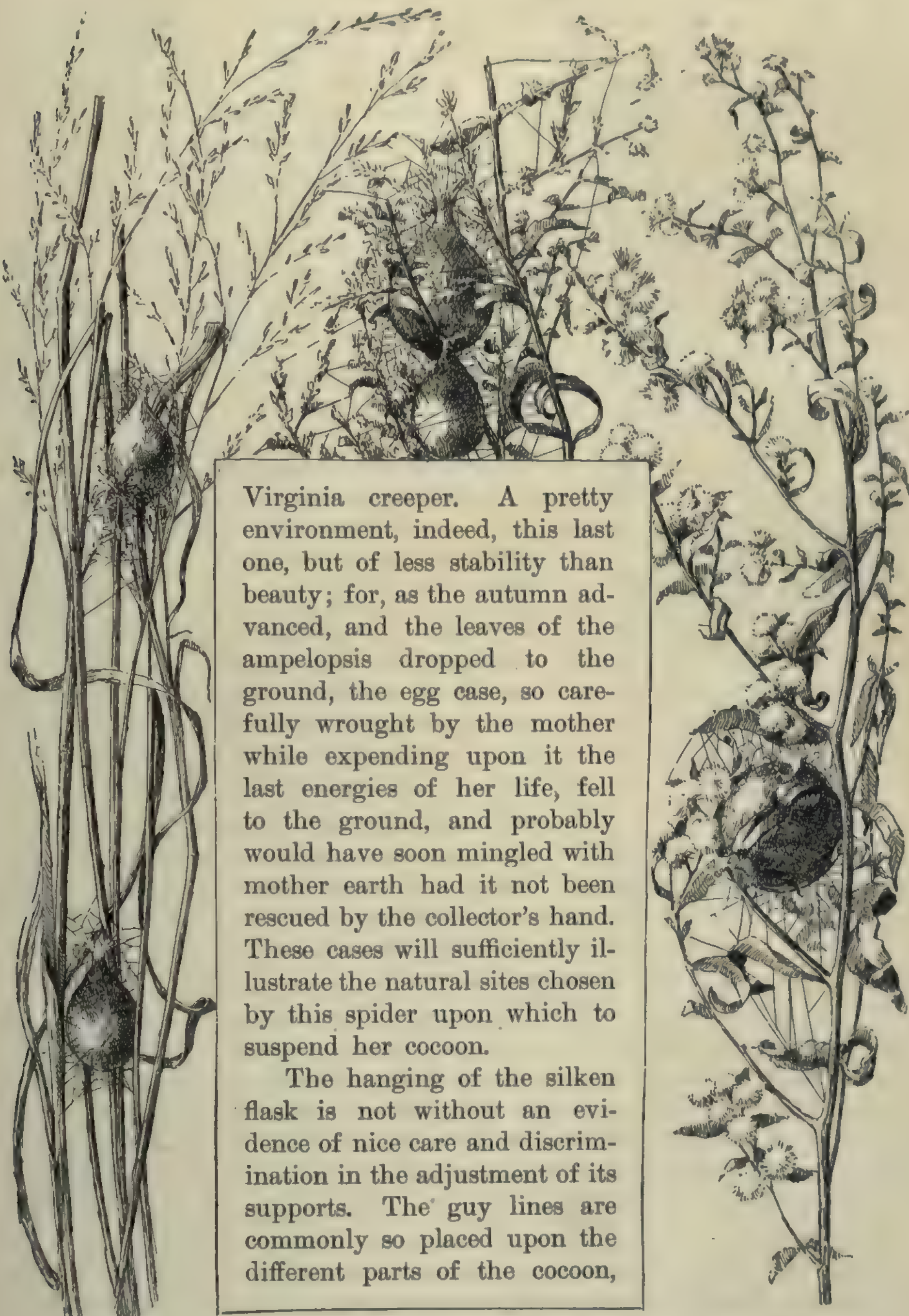
FIG. 38. Cocoon of Argiope cophinaria, hung in the tops of grasses.

Another example is hung in the very midst of a tall field chrysanthemum. The cocoon is much larger than those just described, and is of a rounder shape. Two branches of the plant have been drawn towards each other, and these again towards the central stalk. Within the space thus circumscribed the egg sac is suspended in the midst of a maze of lines attached at one end to the cocoon, and at the other to various parts of leaves and stems of the plant. It is about eighteen inches from the ground, and forms a pretty object amidst the balled white blossoms of chrysanthemum. (Fig. 39.)

Among Chrysanthemums.

A third and fourth specimens are hung in similar positions within the outbranching limbs of a wild flower unknown to me, which is thick set with little white blossoms. Still another is hung within a little canopy formed by the leaves of a blackberry vine, that have the beautiful hues with which, in our climate, the autumn is wont to paint the foliage. Still another is suspended beneath a similar canopy, formed of leaves on a young maple bush. Another has a similar site within the clustered leaves of a fragrant honeysuckle vine; and yet one more has been suspended upon the leaf stalks and under the leaves of our well known

Leafy Canopies.



Virginia creeper. A pretty environment, indeed, this last one, but of less stability than beauty; for, as the autumn advanced, and the leaves of the ampelopsis dropped to the ground, the egg case, so carefully wrought by the mother while expending upon it the last energies of her life, fell to the ground, and probably would have soon mingled with mother earth had it not been rescued by the collector's hand. These cases will sufficiently illustrate the natural sites chosen by this spider upon which to suspend her cocoon.

The hanging of the silken flask is not without an evidence of nice care and discrimination in the adjustment of its supports. The guy lines are commonly so placed upon the different parts of the cocoon,

FIG. 39. Cocoons of Argiope cophinaria, swung among field grasses and wild flowers.

and so stretched and fastened to adjacent objects, that the mother leaves her precious casket so well poised and finely hung that even the strongest wind fails to disturb its balance when a good position has been selected. In this position it will commonly remain until the brood is hatched; but, as we have already seen, sometimes the mother's care is misplaced.

Stability of Poise.

It sometimes happens that the cocoon is simply anchored to leaves, and, when the autumn brings the usual fall of foliage, it is carried down to the ground. There, buried among rubbish, covered with snows and rains, the chances for development of the young are seemingly not very good. Yet even thus it is possible that, in sites comparatively undisturbed by tramping feet of men and animals, the eggs may remain healthful throughout winter, and yield their broodling Argiopes when spring suns dissolve the snow and the spring wind has scattered the leaves.

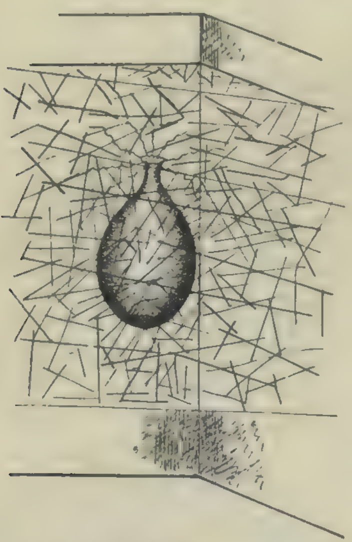


FIG. 40. Cophinaria's cocoon suspended in the angle of a wall in the midst of crossed lines.

It is not an unusual thing for Cophinaria to hang her cocoon in the angle of walls in a house or outbuilding. (Fig. 40.) I have met a number of such cases in the outlying parts of Philadelphia, as, for example, Germantown and West Philadelphia. There still remain in those sections a number of gardens and spacious yards, within which this large and beautiful creature has maintained her position against all encroachments of civilization since the landing of the Swedish pioneers. Their snares are woven upon the vines which cluster about arbors, outbuildings, and verandahs; and it is a common thing for the mother, when the cocooning time has come, to slip underneath a roof or cornice, and there suspend her egg sac.

Indoor Sites.

In this case she protects it by a slender encasement of retitelarian lines spun entirely around it. A cocoon thus disposed is represented at Fig. 40, as it was found in the early summer in the basement of a hotel at Atlantic City. The enclosing lines were from seven to eight inches high, and of about equal width. The lines were much soiled by dust, the accumulation of winter and spring, but the cocoon proved to contain many healthy spiders, although in the lower part it was infested with parasitic ichneumon flies.

Another case of suspension within doors offered an interesting exception to the usual mode. This cocoon was hung in the angle of the walls of a room in Sedgley House, at Fairmount Park, Philadelphia, the headquarters of Captain Chasteau, of the Park Guard, who said that it was made about

October 1st. When first observed, it was a round ball, which was gradually wrought into a pear shaped object. This, when I saw it, was hung from the under side of a sheeted curtain (Fig. 41), that curved over and extended like a bridge from the shield shaped hub of the snare to the adjacent wall. The curtain terminated in a pocket, from the bottom of which the cocoon was suspended. The cocoon was thus just behind the orb which was spun across the angle about seven feet from the floor. The characteristic zigzag ribbon of the web extended well downward, and a number of lines stretched from side to side across the angle, nearly to the floor, forming a convenient gangway for the spider.

Cocoon Hung to a Curtain.

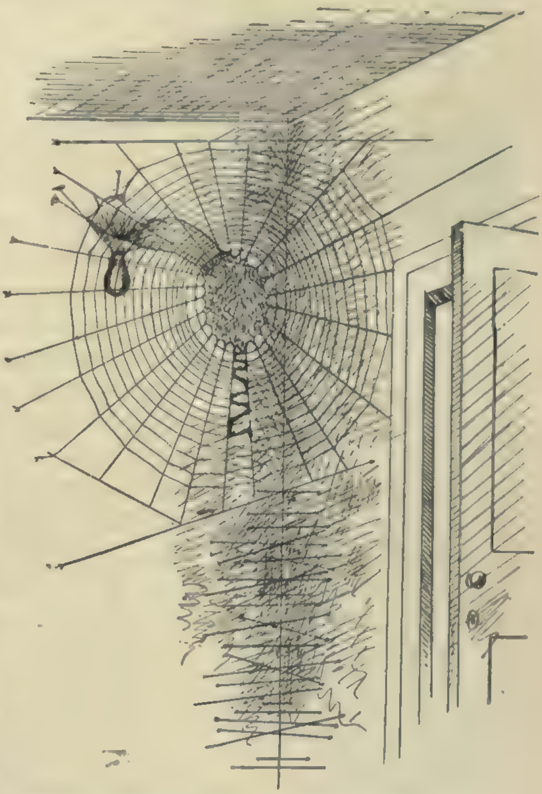


FIG. 41. Cocoon of Argiope suspended from a curtain behind her snare in Sedgley House.

Immediately after finishing her work the mother spider began to languish. She would not take flies as aforetime when offered to her. Once she tried to escape from the room into the Park, but was brought back, and placed upon her lower gangway lines, which she mounted, with great apparent difficulty, to the central shield, behind which she stationed herself. She was found dead upon the floor one morning, having lived only a few days after the completion of her cocoon.

FIG. 42. A round cocoon of Argiope cophinaria.

The cocoons of Cophinaria vary in length from five-eighths of an inch to one inch and five-eighths. Three measurements between these limits are one and a half, one and a fourth, and one and one-eighth inches. The bowl is generally about one inch wide, and the flask one-eighth inch wide at the tip of the neck. The bowls are for the most part decidedly pyriform in shape, but sometimes are spherical instead of oval. As the spiderlings grow a little within the sac after hatching, the bowl somewhat expands, or rather fulls out, but the original shape remains substantially unchanged.

The structure of the cocoon is as follows: First, the outer case or shell

(Figs. 43, 44, o.c) is usually a thin, stiff, parchment like substance, that feels dry, and crackles under the touch, as though glazed. It is substantially water tight. I have found several cocoons of a softer material, and thicker, much like a delicate yellow felt. The glazing above mentioned is not the result of ageing or weathering simply, but is produced by the action of the spider herself, perhaps by the overspreading of the viscid secretion which forms the beads on the spirals of a snare.

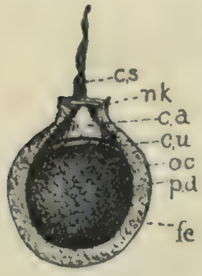


FIG. 43. Section view of cocoon of Argiope cophinaria. fe, flossy envelope inside the outer case, oc; p.d, the brown padding; c.u, the cup or dish against which the eggs (e) are deposited; c.a, cap covering the egg cup; c.s, suspension cord.

When this outer case is cut away there is first presented a flossy envelope (f.e) of soft yellowish silk, which quite surrounds the contents of the bowl. Next is a dark brown pyriform or spherical pad of spinningwork (p.d), which swathes the eggs completely, interposing a thick, warm, silken blanket between them and the external case. On the upper part of this pad is a plate or cup (c.u), of like color and closer texture, with the concavity downward. I have at least once found this to be a whitish disk of stiff silk. The neck or stalk (nk) of the cocoon is filled with a compact silken cone (c.s), of a yellowish or brown color, which is united at the base to the egg plate (c.u), and at the top terminates in a strong twisted cord (c.s), which sometimes extends upwards and forms the central support to the cocoon. Next to the brown pad is often a thin flossy envelope, which surrounds the egg sac. The latter is a rather closely spun pouch of variable tenacity, and whitish or pinkish white color, that encloses the thousand or more eggs which lie in a globular mass within the heart of the cocoon. The inner egg sac (e) is attached above to the plate or cup (c.u), which, after the spiderlings hatch, is pushed upward by them not unlike a trapdoor, permitting them to creep out into the surrounding padding, leaving their white shells within the sac.

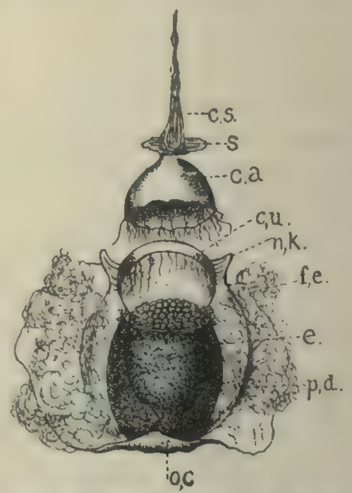


FIG. 44. Cocoon of Cophinaria dissected to show the parts. Letters as in Fig. 43.

The plate serves to support the eggs, which are probably oviposited upward against it. One female, confined within a box, got so far in the construction of her cocoon as to spin the plate, but went no farther, leaving, however, this evidence of the point at which her ovipositing would have begun.

The genus Argiope is widely distributed throughout the globe, and the cocooning habit of the species has elsewhere the same characteristics as in America. Argiope fasciata of Southern Europe and Northern Africa makes

a cocoon much like that of our Cophinaria. Fig. 46 shows the external case, and Fig. 45 gives a section view of the central egg sac, supported in the midst of a bunch of loose flossy silk.[1]

The Egg Mass.

I have found numbers of Cophinaria's cocoons on vacant city lots in Philadelphia, strung to the stems of tall weeds on either side of a well traveled footpath. The mothers had safely passed through the perils of assaulting boys and voracious birds, and left these tokens of their maternal care in this conspicuous spot. As far as examined the cocoons contained broods of healthy spiders. One exception, however, permitted me to see the position and structure of the egg mass. It is a hemispherical mass five-sixteenths of an inch high and wide. The eggs are bright yellow, contained within a delicate white or pink hued membranous silken sac, through which they can be seen in outline.

Variation in Structure.

It is interesting to observe that there is some variety among the mother Argiopes in the manner of preparing a cocoon. I have one before me which is composed, first, of a soft silken exterior case; then, of three easily separated layers of delicate yellow silken tissue, extremely soft and beautiful. Next to these layers is the loose yellow flossy mass hitherto described, and then the brown padding which surrounds the egg sac proper. This brown padding is not as abundant as I commonly find it, for the reason, perhaps, that the yellow silken envelope is so much more pronounced. Another cocoon before me has in it nothing but the brown padding, scarcely a trace of yellow floss, and no layers such as above described. I account for the distinct layers by supposing that they were woven between well marked intervals of resting.

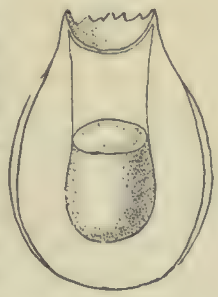


FIG. 45.

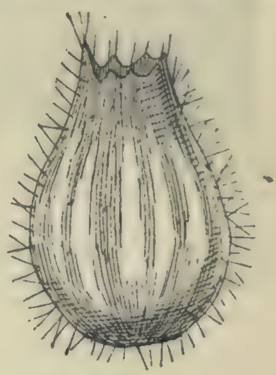


FIG. 46.

FIG. 46. Cocoon case of Argiope fasciata. FIG. 45. Section of same, to show the central egg sac. (After Cuvier.)

Argiope argyraspis.

The Banded Argiope is not as common a spider, at least in the immediate vicinity of Philadelphia, as her congener Cophinaria. Her life appears to be prolonged a little further into the autumn, for I find her upon the bushes when the Basket Argiope has entirely disappeared. Her cocoon is therefore made, as a rule, somewhat later; but it is suspended in a similar manner and in similar sites. I do not find it often, and, as compared with the cocoon of Cophinaria,

[1] Cuvier, Regne Animal, Arachnides, pl. ii.

it is rare. It seems to be less fond of human society, or else less able to stand the exigencies of civilization than Cophinaria. In outlying sections, where Nature has been less disturbed by men, it may probably be found more readily. It is suspended by means of silken guys to the leaves and stalks of grass or low growing plants, which are bent over and also lashed together above the swinging egg nest in the manner represented at Fig. 47. Again, it may be found as at Fig. 48, swung in the midst of a retitelarian maze woven amidst the branches and leaves of a bush, or, as at Fig. 49, seated and suspended in the crotches of a wild meadow flower.

FIG. 47. Banded Argiope's cocoon beneath a canopy of leaves and grass tops.

The shape of her cocoon differs from Cophinaria's in being hemispheroidal instead of pyriform; in other words, it resembles the lower half of a spheroid. Across the wide top is stretched a circular piece of silk, like the head of an Indian drum. (Fig. 50.) The outer case is of stiff yellow silk, as is also the head or top; this part, in a cocoon now before me, is somewhat darker in color than the rest of the case. A marginal flap surrounds the head, and has various points to which guy lines were attached in site. (See Fig. 50.) The height and width of the cocoon are about the same—one-half inch. When the outer case is cut aside, as at Fig. 51, the interior is seen to consist, first, of a yellow flossy envelope, which is packed between the inner wall; and, second, an egg pad, which is not composed of purple silk as in Cophinaria, but of yellow silk plush loosely woven, and is three-eighths of an inch long. Within this are the eggs. Immediately above is the egg cover of white silk plush, which is commonly flat, not concave as with Cophinaria. It is about one-eighth inch thick, and is attached firmly by silken threads to the inside of the top of the case. Against this cover, no doubt, the eggs are oviposited upwards, and are then covered by the mother spider. The portion of the egg cover is shown at Fig. 51, where one edge adheres to the remaining part of the top of the case, and also at Fig. 52, where the object is viewed from the side.

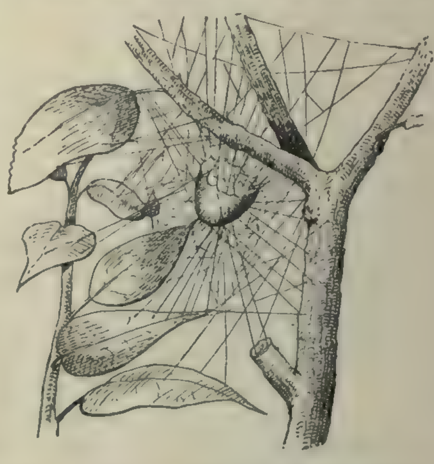


FIG. 48. Cocoon of Argiope argyraspis, suspended amidst supporting cross lines upon a bush.

Among various other examples of California spinningwork received from Mrs. Eigenmann and Mr. R. L. Orcutt, of San Diego, were several cocoons of rare beauty. They were lenticular or hemispheroidal masses, of a yellowish, yellowish green, and green color. (See figures, Plate IV.) They were pulled out into angles at the flat side, as though they had been suspended by threads at the angular points. They varied somewhat in size, from three-fourths of an inch to an inch long, one-half inch wide, and three-eighths high. It was long a matter of wonder and discussion with me what species formed these beautiful egg nests. Mr. Orcutt finally attributed them to Argiope argenteola, without giving a reason for his opinion. The question was at last settled by a living female specimen of that spider sent me by Mrs. Eigenmann, which, happily, reached me alive, but very feeble. I placed her under a trying box, fed her with water and flies, and she revived. The following morning a cocoon was hung within the box, whose shape and color solved the mystery, and proved that Mr. Orcutt was correct in attributing the cocoon to Argenteola.

Argiope argenteola.

This cocoon was a keystone shaped patch of white sheeted silk, upon which was raised a greenish button that enclosed the egg mass. (Fig. 53.) The white color of the sheet can hardly be characteristic, for in specimens before me this part is green.

Fig. 49. Cocoon of Argiope argyraspis, hung upon the stalks and leaves of a wild flower.

The whole was suspended between lines that were attached above to the lower foundation lines of the orb, and to the sides and bottom of the box beneath. Evidently the spider, in spinning her cocoon, had first stretched the sheet, and against or within this had placed her eggs, which she then proceeded to overspin in the usual manner, though, of course, it is not impossible that in this and like cases the cocoon may be framed upon a flat surface and then raised and suspended in the above described position. In general appearance this cocoon resembles that of Epeira rather than the typical Argiope cocoons as represented by our two familiar species, Cophinaria and Argyraspis. But in

the manner of suspension, as well as the character of the egg case, Argenteola resembles her congeners.[1]

A cocoon, when dissected, shows two principal parts—the basal sheet above referred to, and the cup or case which is set upon it. Both these parts consist of closely woven silk, like that which forms the outer case of Cophinaria and Argyraspis, the latter of which it most resembles. This cup is of a yellow or yellowish green color, and the deep green tints appear most decidedly in slight flossy tufts, which here and there overspread it. The inner surface of the basal sheet is overspread with white silk. Within the case is a ball of white flossy curled silk, which forms the inner upholstery of the nest. It thus appears, that while the cocoonery of this remarkable spider resembles that of Epeira in its external shape and the nature of the interior furnishing, yet in the texture of the case and manner of suspension it is like the cocoonery of its congeners. In the example produced in my trying box the basal sheet is hung vertically. If it were suspended horizontally, with the egg case downward (Fig. 54), it would closely resemble an Argyraspis' cocoon.

Fig. 50. Fig. 51. Fig. 52.

Fig. 50. Cocoon of Argiope argyraspis. × 2. Fig. 51. Interior, showing padding, eggs, and the egg cover. Fig. 52. Side view of the egg cover.

Internal Structure

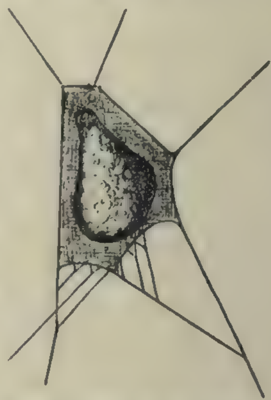


Fig. 53. Cocoon of Argiope argenteola; front view. Natural size.

Mrs. Eigenmann tells me that Argenteola makes more than one cocoon. A specimen which had spun a web in her sitting room placed a cocoon upon it somewhat in the position observed by myself, as above described; but shortly after (the time is not specified) a second cocoon was formed upon the web about two inches below the first one. A few days previous to this cocooning the spider neglected to eat, and paid no attention to the flies placed upon her web. The discoverer had concluded that the creature's mission was ended and death would soon ensue, but was surprised to find

Fig. 54. Cocoon of Argiope argenteola; side view. About natural size.

[1] Koch has described species from South America which closely resemble A. argenteola, and perhaps may be the same. See Arachniden, Tafeln 5–8, Fig. 360, Arg. argentatus, and Fig. 361, Arg. fenestrinus.

its lethargy only the condition naturally preceding cocooning. The second cocoon was a little larger and more flocculent than the first.

After this maternal duty the mother disposed of the flies that were entangled in her web, without any hesitation. This was not the end of the matter, however, for on the 14th of December, just three weeks after the second cocoon had been spun, a third was made, which was likewise attached to the web. On the afternoon of January 6th, three weeks after this last maternal act, the spider lost her grip upon the meshes of her web and fell dead to the floor, having been in the possession of the observer three months.

II.

Epeira Cocoons.

The genus Epeira, which includes our best known and most numerous species of Orbweavers, has little variety among its most typical species in the form of its cocoons, the manner of protection, and nature of sites selected for them. The general form is that of a ball, hemisphere, or semiovoid mass of thick, silken floss, that enswathes a white silken bag, within which a number of eggs, usually yellow, are massed. This is fastened in any convenient and eligible position, attached directly to the surface or hung amid supporting threads. I have stripped from a decaying trunk a bit of bark eighteen inches long, on which one could count forty or fifty of these cocoons intermingled with those of Agalena nævia and other Tubeweavers, and of Laterigrades, as well as the white silken tubes of Saltigrades. (Fig. 55.) Often the dried bodies of the mothers, who had died shortly after their last maternal care and work, were found clinging to the nurseries of their young. When deposited in such sites the eggs rarely have any other protection in the way of spinningwork than the

FIG. 55. Cocoons of Epeira underneath the bark of an old tree.

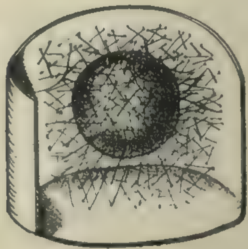


FIG. 56.

FIG. 57.

FIG. 58.

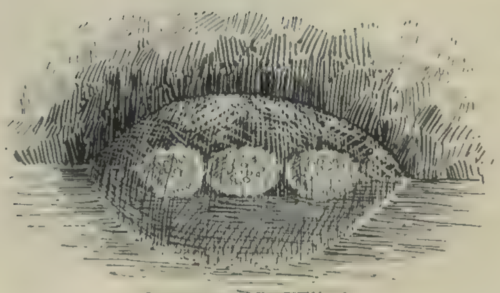


FIG. 60.

FIG. 59.

FIG. 56. Globular cocoon of Insular spider, spun in a paper box. FIG. 57. Cocoon of Epeira insularis, woven against a leaf within a glass tumbler. (Natural size.) FIG. 58. Cocoon of Epeira domiciliorum, within a curled leaf. FIG. 59. Epeira cocoon enclosed within a curled leaf. FIG. 60. Epeira cocoons overspun with a common tent.

flossy cocoon case, the shelter of the bark being, no doubt, sufficient barrier against assault of enemies and stress of weather. A favorite site of this sort is the trunk of an old hickory tree, whose flaky outer bark, curled up at the free ends, offers an accessible retreat.

FIG. 61. Epeira cocoon in angle of a wall, protected by a tent or palisade of lines.

Cocoon of Insularis.

A cocoon of Insularis, in my collection, spun within a small paper box, is a globular ball of yellow silken plush three-fourths of an inch in diameter and of a light yellow color. (See Plate IV., Vol. II.) It is hung against the side of the box (Fig. 56) in the midst of a maze of short right lines an inch and a half wide and high. These lines are knotted together at innumerable points, which are marked by little white dots. This meshed envelope extends nearly to the cocoon, and certainly appears to be a sufficient barricade against hymenopterous invaders, although it was not able to save the eggs from those universal and well nigh irresistible pests of collections, the Dermestidæ. I have another cocoon of this species similarly disposed within an inverted glass tumbler, under which the mother had been confined. She attached herself to the bottom of the glass (the top when inverted), and, as is the custom of her kind, hung there back downward until the period of cocooning. (Fig. 57.) Not long after she died, and her dried up form is partly shown in the drawing. The spots upon the glass represent the points of attachment for the supporting lines of the cocoon, and are little pats of adhering silk.

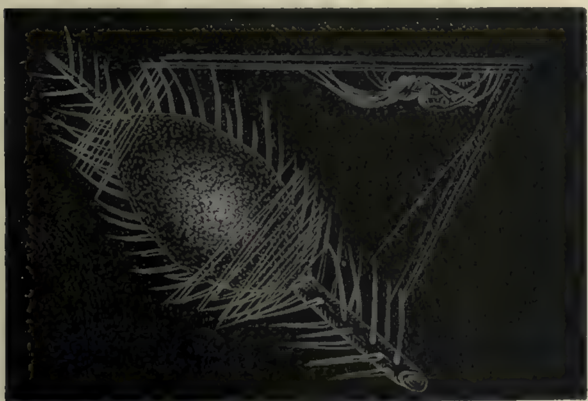


FIG. 62. Cocoon of Epeira domiciliorum, woven upon a pine tree.

Sometimes cocoons are found laid against a leaf which has been drawn around it, as at Figs. 58 and 59, reminding one of the manner in which certain lepidopterous larvæ protect themselves before they pass into the pupa state. When this sort of protection is secured for the eggs, viz., a leafy covering around the egg pad, no further envelope is added, precisely as when the eggs are laid upon the under side of bark and stones.

In other cases, however, as in the angles of walls, porches, outhouses, etc., the silken egg pad is itself enclosed in a tent of spinningwork more or less open. (Fig. 60.) In some cases this tent is little more than a series of lines drawn across the angle at a little distance from the cocoon, as at Fig. 61. Strix, Sclopetaria, and Domiciliorum are all in the habit of weaving around their cocoons such a tent.

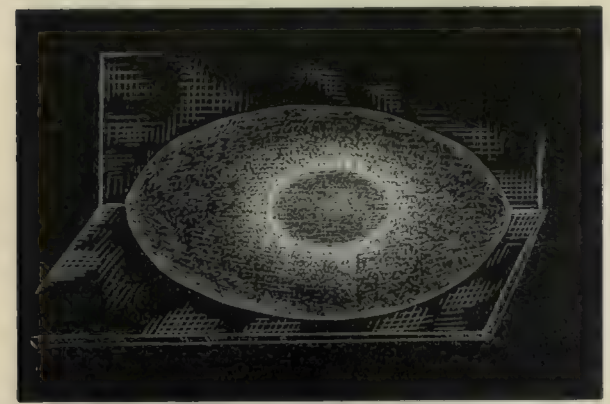


FIG. 63. Epeira cocoon protected by a tent of close spinningwork.

Cocoons in Tents.

A Domicile spider, which I found in the act of completing her cocoon, was content with a scantier covering than this. Her egg sac was an oval mass of yellowish brown silk one and one-fourth inch long by three-fourths of an inch wide. It was fastened upon a twig of a pine tree. At one end short lines were thickly strung across from the needle like leaves, making a sort of "fly" or awning. This was repeated at the other end, thus about half covering the cocoon. The mother spider hung to a few threads above (Fig. 62) her egg nest, with shrunken abdomen, and so much exhausted as to be little inclined to move. This cocoon was made September 24th.

Sheeted Tent.

For the most part the outer tent is of closer texture than those above described, being in fact an enclosing curtain of silken cloth, through which the outline of the cocoon within may be traced. (Fig. 63.) Great numbers of these tent enclosed cocoons may be seen at the boat houses near the Inlet of Atlantic City and Cape May. They are made during the last days of May and to the middle or last of June, and again in the fall.[1] The cocoons measure seven-eighths of an inch long by six-eighths of an inch wide, and less. The enclosing tent measures two and two and a half inches long by one and three-eighths inch wide. Frequently the tents are overlaid one upon another, or spun close to each other, as at Fig. 58. I have found three large cocoons thus

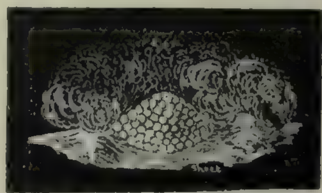


FIG. 64. Egg mass of Epeira, showing the under sheet and the mass of flossy padding.

Foreordination in Nature.

[1] Of two specimens of Epeira sclopetaria kept by me, one cocooned May 22d; the other May 26th; a third about the middle of June. An Epeira domiciliorum cocooned September 16th.

overlaid, and the outer tent, four inches long, covered the others so completely that one might have supposed the whole to be the work of one spider. Undoubtedly, these works are precautions against both enemies and the weather, which, although without experience of the effects of either upon her offspring, the mother takes as though she really foresaw the danger.

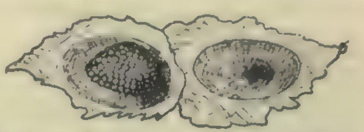


FIG. 65. Egg mass of Epeira, showing the under sheet and outer covering removed.

Interior Structure

If an egg nest of this class be opened there will be found, in order, first, the outer tent, separate from the covering of the cocoon; second, a thin white silken sheet, which is the outer envelope of the cocoon proper; third, the thick egg pad of curled silk, usually yellow; fourth, the eggs, a conical or hemispherical or spherical mass of small yellow globules. (Fig. 64.) When the spider oviposits against a flat surface, the eggs are generally laid upon a coating or sheet of silk spread upon the surface, and the padding is then woven over it in the manner of Argiope cophinaria. If the cocoon is suspended within a maze of lines, the eggs are laid in the midst of the curled nest or egg pad, which is afterwards completed.

The cocoon of Epeira cinerea shows a variation from the common type of her congeners. The egg pad is a large flattened hemisphere, an inch in diameter, and one-fourth to three-eighths of an inch thick. This is spun against some flat surface, the boards of a shed, as I have seen it, upon a light cushion of curled yellow silk. Over and around this, on all sides, is woven the egg pad, which is flattened down quite compactly, and the whole mass lashed at the edges to the surface. The entire cocoon has a diameter of one and five-eighths inch or more, and is a quarter or three-eighths of an inch thick at the centre. (Fig. 66.)

FIG. 66. Cocoon of Epeira cinerea.

III.

Epeira triaranea.

Epeira triaranea makes a cocoon of the common type, but smaller. Of two now before me, spun in bottles, one measures one-fifth of an inch, and the other about half that. They are both round or ovoid flossy masses, protected by a maze of intersecting lines spun around them. This maze is often thickened into a tent, in which condition I have observed numbers spun in the angles of the joists of a cellar at Atlantic City, in the early spring (May 22d), full of young spiderlings just ready to emerge. These cocoons measured one-half inch long, which is somewhat above the normal length.

One female was observed (New Lisbon, Ohio), whose cocoon was wrapped up within a rolled leaf. This was swung to a cord, attached at one end

to the silken, bell shaped tent within which the spider nested, and at the other end to the fence top against which the tent was placed. (Fig. 67.) In this way the mother had her future progeny literally "cradled," and in good position also to be freely "rocked." What freak had caused her to make this divergence we can only conjecture; probably the cocoon had first been spun upon the leaf, which, becoming loose, and threatening to fall, was secured in the manner described.

A familiar resort of Triaranea in New England is the stone wall, characteristic of that section. Underneath the irregular slabs or boulders of granite which are heaped, one upon the other, to form the division fences between meadows, etc., I have found large numbers of this species. The orb, which is usually about six inches in diameter, is woven within the interspaces of the rocks, and the spider has her resting place against the rough surface, or within the little indentations of the stone which forms the top of the cavity. Against this surface the mother Triaranea weaves her bowl shaped tent, and against the same surface, an inch or two away, she spins her cocoon. This is about a quarter or three-eighths of an inch in diameter; is a hemispherical disk of flossy white silk, which is overspun by a stiff, taut, close, but transparent tent of white silk about three-fourths of an inch long. This may be considered the typical cocoon of the species.

Stone Fence Colony.

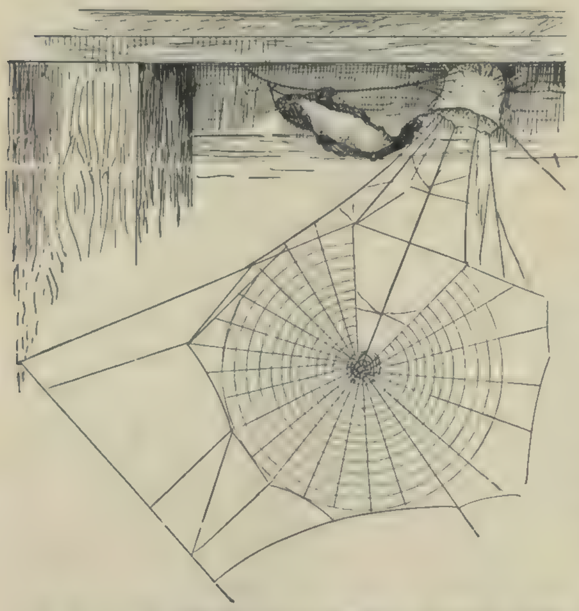


FIG. 67. Leaf enclosed cocoon of Epeira triaranea, swung to her silken nest and above her snare.

The number of eggs in three cocoons counted was, respectively, forty-five, forty-two, and thirty-two. They were of a gray color. Little spiders had just developed in one, and these had yellowish abdomens, round, and very slightly oval, with the legs white. The egg skin had just been cast, and the little fellows were stretching themselves and straggling about in a feeble manner.

One female was resting within a circular depression underneath a rock, and had spun a few silken lines, forming the foundations of a little circular tent, the framework of which extended downward toward her snare. Within this was an old empty cocoon, against which the spider rested. Near by was a fresh cocoon, nearly one-fourth inch in diameter, overspun by a

tough silken tent, and this appeared to belong to the spider, who, moreover, looked as though she might soon make another cocoon. The question was started, but was not solved, does Triaranea weave more than one cocoon? The cocoon was a little flossy ball, flattened, of course, on the side attached to the rock. I captured one of the females, which cocooned in a box, thus showing that the cocoons above described were those of this species.

FIG. 68. Cocoon of Epeira thaddeus, swung upon a line.

A cocoon of Epeira thaddeus was sent to me from Vineland, by Mrs. Mary Treat. It had been spun upon some potted ferns within her lodgings. It is a subglobose sac, of a delicate pearl gray color, one-fourth inch (six millimetres) in diameter. It is attached at the top to a strip of silk ribbon, or rather it widens out at the top into two triangular points, by which it is fastened upon a cord stretched between two sprigs of fern. The egg ball thus swings free. (Fig. 68.)

Epeira thaddeus.

I have secured cocoons of this species, by confinement within the trying box, which differ from the above. They are globular or subglobular masses of flossy yellow silk, about three-eighths of an inch in diameter. I believe that, ordinarily, Thaddeus will be found to weave a cocoon of this sort upon a leaf or other surface, probably enclosing it within a curled leaf, or overspinning it in the manner of Epeira triaranea.

I have not been fortunate enough to identify the cocoons of our common Zillas; but a species which I observed in Florida made a cocoon shown at Fig. 69, top of the cut. It was a flossy ball, about three-eighths of an inch thick, and was woven within the silken tent which formed the spider's domicile. It was placed in the top of the tent, and against the twigs, which formed a sort of framework for it. After the cocoon had been made the spider shifted her domicile to a lower point, and gradually spun a new dome shaped tent just beneath her cocoon, within which she continued to dwell.

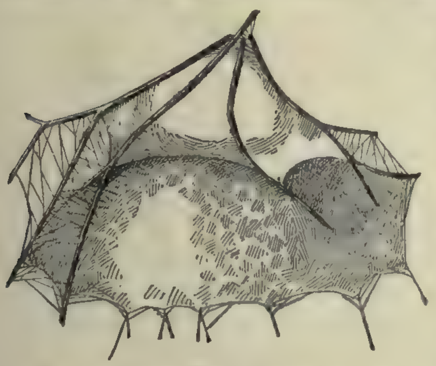


FIG. 69. Cocoon (top of figure) and tent of a Florida Zilla.

The cocoon of Nephila wilderi, according to Professor Burt Wilder,[1] is a large flossy hemisphere of silk, which is usually spun upwards against a leaf or similar surface. The spinningwork

[1] Trans. Am. Assoc. Advanc. Sci., 1873, page 263.

Fig. 70.

Fig. 71.

Fig. 70. Cocoon of Nephila wilderi, woven against a leaf. (After Wilder.)
Fig. 71. Cocoons of West Indies Nephilas spun on plants. (After Wood.)

is of a yellow color, and so slight as to show the loose mass of eggs within. (Fig. 70.) It appears to resemble quite exactly the cocoon of its congeners in Africa and the West India Islands.

Nephila Cocoons. For example, the cocoon of Nephila nigra, according to Dr. Vinson,[1] is of a beautiful yellow color, and is attached to the bark of trees, or spun against the surface of some recess. Nephila maurata spins a large cocoon, of a beautiful orange yellow color. This is not attached to her snare, but is woven against any adjacent recess, or in some shaded place near to her, although sometimes she goes quite a distance from her web to find a cocooning site. The orange colored egg sac is enclosed in a flossy envelope of a paler color.[2]

Fig. 72. Cocoon of a California Gasteracantha, woven upon curled leaves.

If we may credit the statement, or rather the illustration of Mr. Wood, the Nephilas of the West Indies, which are there known as the Tufted spider, spin a cocoon similar to that described, but suspended to the stalks of various plants, instead of being hung beneath leaves or woven against hard surfaces.[3] The figure presented by Mr. Wood, and which is here reproduced, is said by the author to be made from specimens in the British Museum, although I do not remember to have seen these when examining the collections of spinningwork at Kensington several years ago.

IV.

I have several cocoons of our American Gasteracantha, two of which were sent from Southern California by Mrs. Eigenmann. A third was woven by a living female sent from the same section; and a

Gasteracantha. fourth was received from Dr. George Marx, of Washington. The latter is attached to the bark of a twig, upon which it is spun. It is a flossy button or wad of a bright yellow color. The outer strands of the spinningwork have a glossy appearance. It is about three-fourths inch long and one-half inch wide. (Fig. 72, and Plate IV., Vol. II.) The California examples are smaller but similar.

These cocoons are, in structure, like those of their African congeners as described by M. Vinson.[4] This author describes a cocoon of Gasteracantha bourbonica as an ovoid, round and flattened, woolly wad of a yellow

[1] Araneides des Madagascar, etc., page 191. [2] Idem, page 186.
[3] "Homes Without Hands," page 584.
[4] Araneides Réunion, Maurice, et Madagascar, page 238.

and green color. The case which envelops it is twenty millimetres long, and the central egg mass measures four-fifths of an inch (ten millimetres) in width. The centre, which contains the eggs, is white, but grows brown from the moment of enclosure.

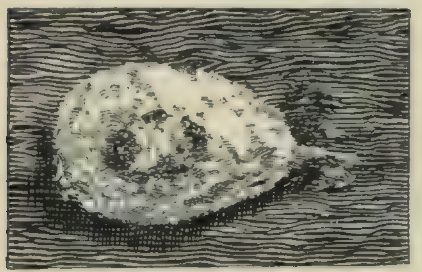


FIG. 73. Cocoon of Meta menardi. (About one-third larger than natural size.

Meta menardi.

The cocoon of Meta menardi, as I have found it, is a somewhat oblong roll of brownish silk, not very compact in texture, but sufficiently open to allow one to see the eggs enclosed within. It is deposited near the snare of the female, and simply attached to some surface by a rather sparing system of supporting lines.[1] According to Blackwall, the species (Epeira fusca) as observed by him in North Wales makes a cocoon somewhat different from this. In autumn the female fabricates a large oviform cocoon of white silk, of so delicate a texture that the eggs, connected together by silken lines in a globular mass a quarter of an inch in diameter, may be seen distinctly within it. Its transverse axis measures about eleven-tenths of an inch, and its conjugate axis eight-tenths. It is attached by numerous lines, generally forming a short pedicle on one extremity to the walls or roofs of the places it inhabits. (See Fig. 74.) The eggs, which are yellow and spherical, are between four and five hundred in number.[2] The general characteristics of the cocoon as thus described by Blackwall correspond with those of the American species, except in the habit of suspending the cocoon by a short pedicle. However, a wider observation of the American species might show even closer resemblance in cocooning habit. One or two of my specimens have a little tuft at one pole, as though a slight stalk or attachment had been there made.

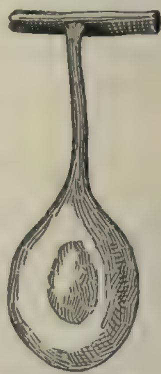


FIG. 74. Cocoon of English Meta menardi or Epeira fusca. (After Blackwall.)

Tetragnatha's Cocoon.

The cocoon of Tetragnatha extensa is a pretty object. I have never seen the mother weaving it, nor have I obtained it by confining the female within my trying boxes. But I have found it in the fields, where one may identify it by its resemblance to that spun by European individuals of the species; and, moreover, I have hatched the young, and thus demonstrated the true cocoon. It is an ovoid object, about quarter of an inch long and three-sixteenths of an inch wide and thick, and is commonly woven against a leaf, or twig, or bit of bark, or other convenient

[1] Mr. Isaac Banks has also found it thus placed in Central New York.

[2] Blackwall, "Spiders of Great Britain," page 350; and pl. 26, Fig. 252, g.

object. (Figs. 75, 76.) I have found what I suppose to be this cocoon, suspended by four diverging lines within an open space, as, for example, in the post hole of fences, as shown at Fig. 77. The cocoon varies somewhat in color, being usually of a cream white tinted with green. The silk looks almost like wool. The exterior is covered with little points or minute projecting rolls, in this respect somewhat approximating the cocoon of Uloborus. Within this exterior case are found the eggs, which are overspun by a slight flossy covering.

The European Species.

The English species forms its cocoon in June. It is described as roundish, less than one-fourth inch in diameter, fine and slightly woven; and is either whitish with greenish tufts, or greenish with whitish tufts upon its surface. The cocoon is fixed to some object near the web, and contains pale yellow eggs.[1] This corresponds substantially with the account of Walckenaer, who describes the threads of the interior as of a bluish green color, but the exterior as a little browner in hue, and presenting inequalities as of little globules produced by the eggs.[2] Lister also describes the cocoon, which he frequently found attached to the joints of twigs and to the leaves of plants. Thus it was nearly or quite the first example of spider cocooning to attract the notice of naturalists.

V.

Spiders with Several Cocoons.

Most Orbweavers habitually make but one cocoon. There are some exceptions, however, among them two species very common in the United States, viz., the Labyrinth spider and the Tailed spider, which distribute their eggs in several cocoons, as does also Epeira bifurca of Florida. A rarer species having the same habit is the Basilica spider; Uloborus plumipes and Cyrtarachne complete the list of Orbweavers known to me to habitually construct a string or cluster of egg sacs. These species represent groups having well defined differences in structure and decided differences in the characteristics of their snares.

Cyrtarachne bisaccata.

The genus Cyrtarachne is remarkable by the peculiar form of the body, and is distributed quite extensively throughout the United States. There are probably two species, the Bisaccata of Emerton and Cornigera of Hentz. The cocoon made by the two species is similar in general form, but there appears to be a marked difference in the mode of attachment. Moreover, Cornigera apparently spins but one cocoon, while Bisaccata, as its name implies, spins at least two; and I have had cocoon strings sent me from California by Mrs. Eigenmann containing three. Thus Emerton's specific name appears to be a misnomer. I have a number of specimens; one collected by Dr. Marx

[1] Staveley, "British Spiders," page 268. [2] Aptères, Vol. II., page 207.

FIG. 75.

FIG. 76.

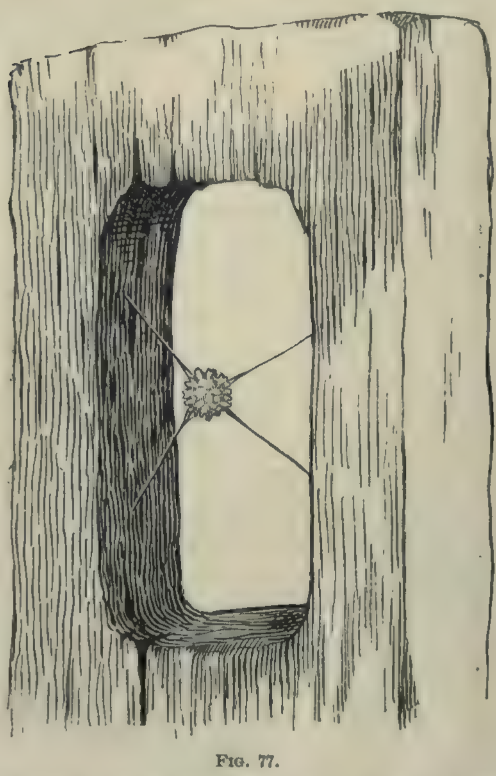


FIG. 77.

Cocoons of Tetragnatha extensa: FIG. 75, spun upon a leaf, × 3; FIG. 76, woven against a twig, × 3; FIG. 77, suspended within a fence post hole, the last about natural size.

at Washington, D. C., a single cocoon; another containing two cocoons, sent to Dr. Marx from Fort Yukon, Alaska. Still others were forwarded to me from various parts of the country.

Distribution. The range of the species is, therefore, evidently from the southern extremity of California to the Alaskan peninsula on the west, and in the east along the New England coast, and as far south at least as Washington.

Several of my specimens are fastened to the twigs upon which they were woven, and give a correct idea of the ordinary manner of attachment. The cocoons are about three-eighths of an inch in length, with a foot stalk of varying length, which gradually ends in a fine thread stretched upward along the twig. One example, containing two cocoons, is lashed against a twig by an overlying cord of yellowish silk five inches long. The cocoons are composed of dark brown or bluish silk, with overspread tufts or patches of white. They are separated by a space of nearly half an inch, and the foot stalk of the lower cocoon is united to the bottom of the upper one by a thick, stiff, blackish cord.

FIG. 78. Cocoons of Cyrtarachne suspended against a twig. Natural size.

The lower portion of the ball of the egg sac has a scalloped fringe with blunt points or processes, which, as far as my specimens show, have nothing

Scalloped Fringe. to do with the manner of suspension. Nevertheless, they may serve some useful purpose in anchoring the egg sac to the twig. This description will fairly represent the form and mode of suspension of all my specimens.

Emerton found his specimens at New Haven, Connecticut, on a beech tree. They were dark brown, as dark as the bark of the tree, and as hard. Around the middle of each was a circle of irregular points. One of his cocoons was attached by a string to the bark, and the other was attached in the same way to the first cocoon. The spider held on to one of the cocoons, which, therefore, had probably been recently spun. We may safely conjecture the date of this observation, October 22d, to be the cocooning period of this species. The following spring another similar pair of cocoons was found on a low oak tree in the same vicinity, still firmly attached to the bark. From these the young came out in June.

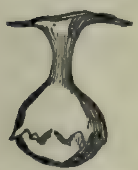


FIG. 79. A single cocoon of Cyrtarachne bisaccata. (After Emerton.)

In my specimens there is much difference as to the regularity of the little exterior processes or points alluded to. In some specimens they are quite regularly formed, and make a very pretty ornament upon the

cocoon. In others they are quite irregular, not only in their shape, but in the mode of arrangement, being little more than irregular nodules upon the surface. One of the specimens from California consists of three cocoons, the first of which has the points arranged with considerable regularity, while the others are less in size and are almost without rugosities. All have little openings towards the top, through which, no doubt, the spiderlings made their escape. (See Fig. 80, which shows the cocoons natural size.)

FIG. 80. Cocoon string of a California Cyrtarachne, seen from two sides. Natural size.

Cyrtarachne Cocoons.

Cyrtarachne cornigera is quite as remarkable in the character of its cocoon as in its own structure. This cocoon is a flask shaped object, resembling that of Argiope riparia, but with a neck relatively much longer. Two examples before me differ greatly in size, one being more than one-third larger than the other.[1] In the former the stalk or neck is of uniform thickness; in the latter it is twice as thick at the mouth as at the bowl. (Fig. 81.) The cocoon is lashed at the base of the bowl to a twig by a number of silken threads, which are attached to one side, carried quite around the twig, and similarly fastened to the opposite side. The entire lower half of the bowl is thus covered by the attached wrappings, which are drawn so tightly that the flask sits quite firmly upon the twig. At the opposite end the cocoon is stayed by lines that pass from the tip of the stalk to the snare of the spider or other support. The attachments of these guys are shown in Fig. 81, which is drawn twice natural size.

FIG. 81. Cocoon of Cyrtarachne cornigera, lashed to a twig. × 2.

In the Camden cocoon (Fig. 82, natural size), the lashings are of a

[1] No. 1, collected by Mr. Isaac Martindale, Camden, N. J.; length, 19 mm.; bowl, 10 mm. long, 9 mm. wide; stalk, 9 mm. long, 3 mm. wide. No. 2, collected by Dr. George Marx, Washington, D. C.; length, 12 mm.; bowl, 6 mm. long, 5 mm. wide; stalk, 6 mm. long, $1\frac{1}{2}$ to 3 mm. wide.

yellow, glossy silk, and so abundant as to make quite a ribbon. Here the threads are carried around both sides of a projecting twig, as though the spider mother had purposely availed herself of this mechanical advantage, and are additionally strengthened by being crossed or twisted as they pass around the branch to which the cocoon is attached. The outer envelope is in color a very dark yellowish brown, and is of extraordinary stiffness. When cut open the bowl is found to contain a ball of white silken floss, within which the eggs are deposited. This ball is fastened to a very tough twisted cord, that passes up through the neck (Fig. 83), and which is the line by which the egg ball was suspended before the outer flask was spun around it. The texture of the external shell has every appearance, under the lens, of having been hardened by means of a viscid secretion applied to it by the spider; the toughness is evidently not the result of simple weaving.

Fig. 82.

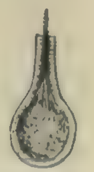


Fig. 83.

Fig. 82. Cocoon of Cyrtarachne cornigera (natural size), in site upon a twig. Fig. 83. Interior view of same.

Another example of Cornigera's cocoon is drawn at Fig. 84. The manner in which the bowl of the vase shaped object is seated upon the twig and lashed by a ribbon is there well shown. The top of the stalk is stayed by various lines wrapped about a neighboring twig.

Labyrinth Spider.

Epeira labyrinthea belongs to the small group of Orbweavers that spin compound snares; that is, snares in which the orb is associated with a well developed retitelarian snare.[1] The labyrinth of crossed lines is placed behind and above the orb, and within this the spider has her dwelling, commonly beneath a dry leaf; here also she suspends her string of cocoons, placing them near her tent, and usually above it and to one side, as represented in Fig. 85.

It consists of several, usually five, lenticular or semiglobular vessels, of a yellowish, tough texture, about one-fourth inch long and one-sixth wide. These may be properly described as woven dishes with covers. Each cocoon consists of two disks joined together at the edges tightly enough to cause them to adhere until the parts are gradually loosened before the strain of the growing spiderlings, and finally open up and permit the inmates to escape.

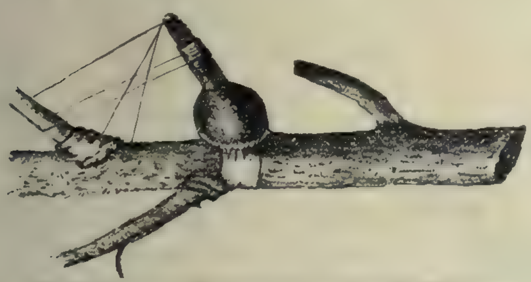


Fig. 84. Cocoon of Cyrtarachne cornigera, with ribbon lashing and stay lines.

[1] See Vol. I., page 131, and Fig. 115.

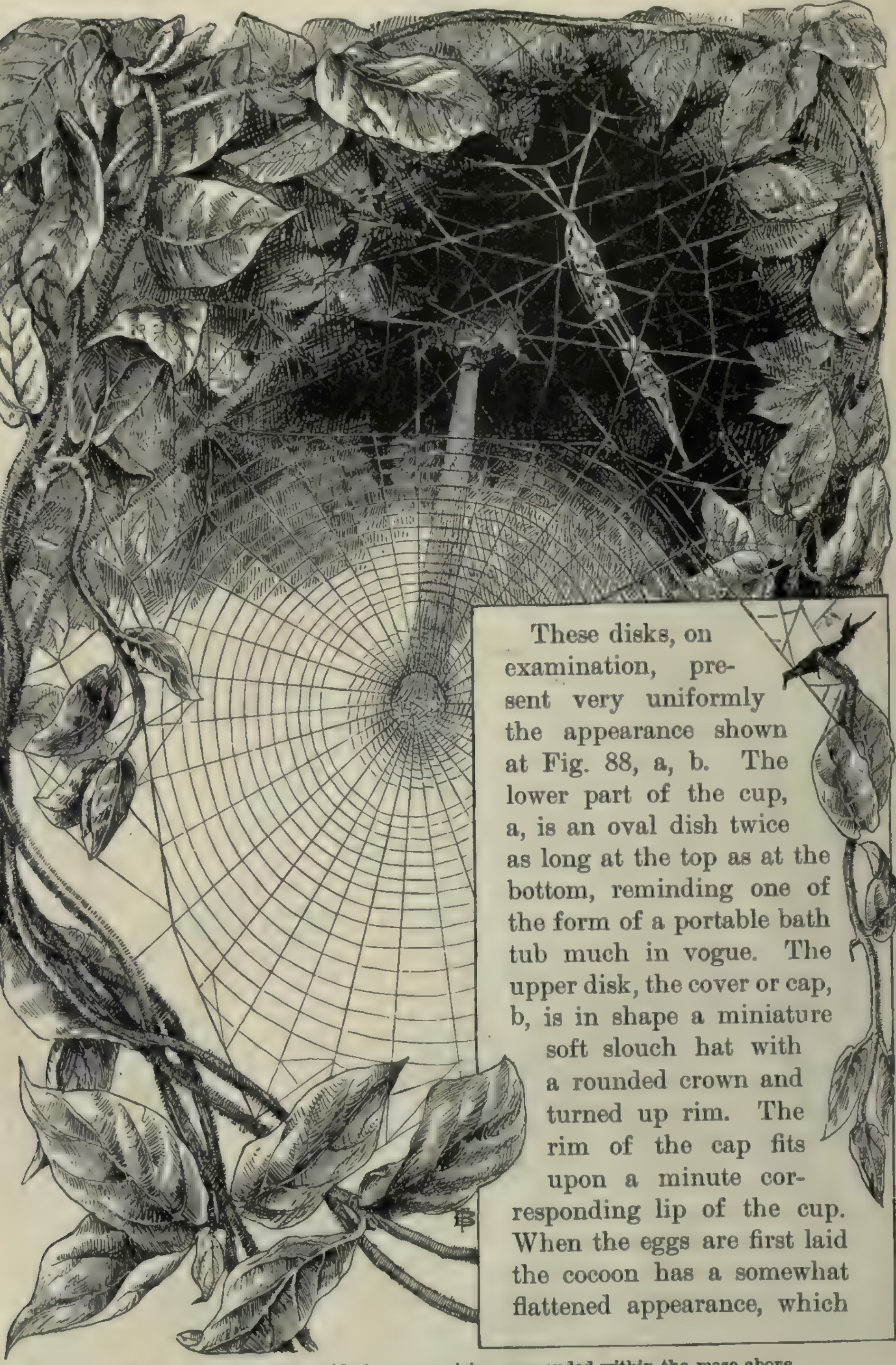


FIG. 85. The Labyrinth spider's cocoon string, suspended within the maze above her leaf roofed tent.

These disks, on examination, present very uniformly the appearance shown at Fig. 88, a, b. The lower part of the cup, a, is an oval dish twice as long at the top as at the bottom, reminding one of the form of a portable bath tub much in vogue. The upper disk, the cover or cap, b, is in shape a miniature soft slouch hat with a rounded crown and turned up rim. The rim of the cap fits upon a minute corresponding lip of the cup. When the eggs are first laid the cocoon has a somewhat flattened appearance, which

in many cases (not all) becomes much rounded as the spiders grow. If the cap be lifted up or pulled off, as may readily be done when the young are nearly ready to emerge, a ball of yellow silk will be found inside, amidst which the eggs are originally deposited, and in whose fibres the spiderlings burrow. The cocoons are in number about five, more or less, and each one contains about twelve to twenty eggs, so that the aggregate number of eggs is about equal to that found in the single cocoons of some other species.

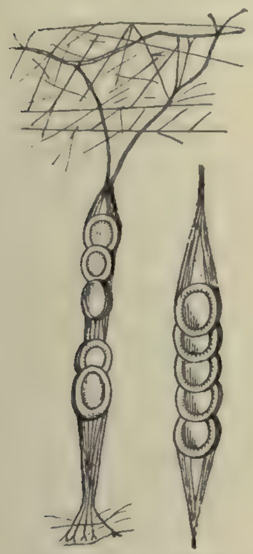


FIG. 86. FIG. 87.

Cocoon strings of Labyrinth spider. (Natural size.) FIG. 86. The manner of lashing above. FIG. 87. The tiled position of the cocoons.

FIG. 88. The dish, a, and cover, b, of a Labyrinth spider's cocoon.

For the most part the cocoons overlay one another, the top of each projecting one-third to one-half its length over its neighbor, as shown at Fig. 89, i, front view; ii, back view. They are held together chiefly by a band of loose threads (o, ii) which are stretched along the back parts of the cups, although at the points where the cocoons overlap they are also lightly attached. The band upon which the cocoons are thus strung is fastened to a strong, thick, branching white cord, which is anchored above and below to the network of cross lines. This cord is usually longest above, deltated and often suspended upon a similar transverse cord. (See Figs. 85, 86.) When the cocoons are opened in October, the spiderlings are found fully developed, lively, and ready to escape. They resemble the adult form in markings.

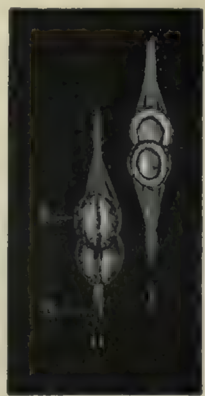


FIG. 89. Two overlaid cocoons of Labyrinthea, showing the cord i, and ii, o,'x, upon which they are strung. (Natural size)

The cocoons are sometimes separated from each other, as at Fig. 86, but again are all overlaid, Fig. 87, being lashed together by the band of threads upon which they are strung. Occasionally, the spider will spin her tent beneath the lowest cocoon of the series, instead of the usual leaf or other débris, and will be found backed up against the same, holding to the trapline of her snare. (Fig. 90.) The full page cut (Fig. 85) shows Labyrinthea's cocoons strung in natural site, above and behind the leaf-roofed tent.

The mother begins to spin her cocoons in August, adding one every week, or thereabouts, until the tale is complete. The suspensory cords that support the cocoon string are strong, thick, and of a pure white color. I have found numbers of the empty cocoon shells in

the early spring, hanging intact upon the bushes where they had been placed, although, of course, the snare had entirely disappeared.

Cyclosa caudata.

The Tailed spider, Cyclosa caudata, differs from Labyrinthea in the mode of hanging her string of egg sacs. This is suspended within the limits of her orb, above the central space, along the line of the perpendicular. As the cocoons increase in number, the adjacent radii and the connecting spirals are cut out, leaving a clear segment resembling that in the snare of Zilla, in the middle of which the cocoon string hangs. (Fig. 92.) The number of cocoons appears to vary much; I have usually found from three to five; Hentz never observed more than five.[1] They are generally in shape a double cone, although often round or roundish, and are from three-sixteenths to quarter of an inch (five to seven millimetres) long and one-eighth inch (three millimetres) wide. A cocoon is not composed of two distinct parts, like one of Labyrinthea's, but is spun in a single piece of soft yellowish floss, externally close enough to be weatherproof, but which ravels out into woolly threads when picked with a needle.

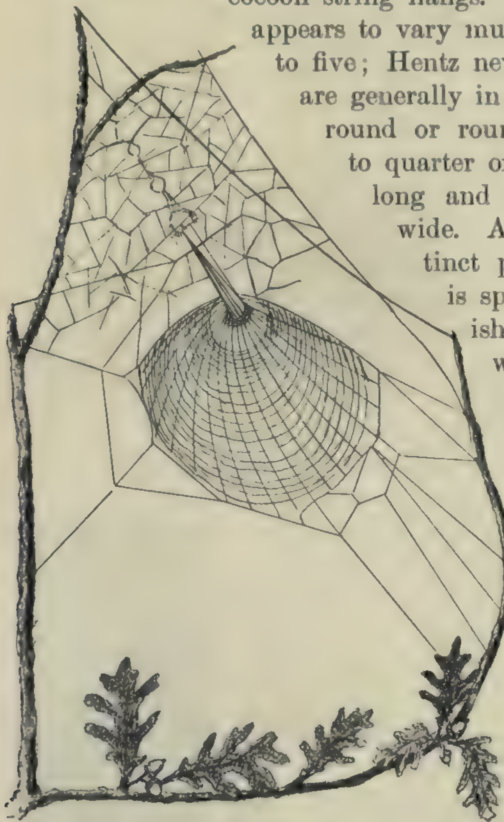


FIG. 90. Labyrinthea's snare, viewed from behind, with two cocoons in site above the tubular nest.

Within, the sac is filled abundantly with delicate, flossy, yellow silk, in which the eggs are deposited. These vary in number; for example, three now before me, opened in succession, contain, respectively, twenty-two, two, and ten; certainly a remarkable difference. On one occasion a female enclosed within a paper box began to make a cocoon, but proceeded no further than to weave a tiny saucer, similar to that spun by Argiope riparia. This would, therefore, appear to be the commencement of her cocoon, and it may be that against such a disk Caudata habitually deposits her eggs before enclosing them. However, I have not found this within her cocoons, as is the case with Argiope's, and conclude that the disk is made the basis of the external sac, into which it is woven as the spider proceeds. The cocoons are often well separated upon the string, but also are found touching and even over-

[1] "Spiders United States," page 127.

lapping one another like tiles. Sometimes nodules of flossy silk, or of silk mixed with the débris of captured and devoured insects, are irregularly interposed between the cocoons. This is, indeed, a fixed and most interesting habit of the species, which will be described in a succeeding chapter.

Fig. 92. Section of Caudata's snare, showing manner of suspending cocoons. (Natural size.)

During a temporary stay in Florida, April, 1886, I found nested upon the porch of Dr. Wittfeld's place, Fairyland, Merrit's Island, on the Indian River a little way below Rockledge, a new spider, which I named Cyrtophora bifurca. Its snare resembles that of Cyclosa caudata. It also resembles that spider in the manner of hanging its cocoon string in the vertical axis of its orb just above the hub. The character of the cocoon, however, differs entirely from that of Caudata. It is, in shape, a somewhat irregular octagon, and is of a dark green color. I have found as many as fourteen cocoons in one string, overlapping one another in the manner of cocoons of the Labyrinth spider, and which may also be seen at times with the cocoons of Caudata, although for the most part, the latter are arranged at intervals along the string. (See Figs. 96, 97.)

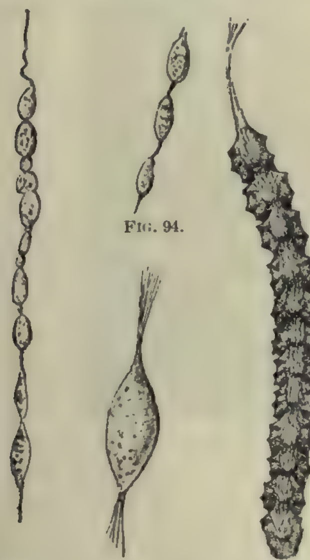


Fig. 94.

Fig. 93. Fig. 95. Fig. 96.

Fig. 93. Cocoon string of Caudata, with silk nodules interposed. (Natural size.) Fig. 94 (upper). Cocoons. (Natural size.) Fig. 95 (lower). Enlarged. Fig. 96. Cocoon string of Epeira bifurca, showing shape and superposition. (Natural size.)

The cocoon strings collected varied in the number of cocoons attached thereto, probably according to the period of advancement in the process of ovipositing on the part of the mother. Of the specimens collected one string contained fourteen, another twelve, and another ten cocoons. They are bound together, along one side, by continuous series of thick white threads, which extend from the top to the bottom of the string. Each cocoon consists of two parts, which have evidently been fastened together by a selvage. These parts present the appearance of two dishes placed together edge to edge. They are woven of a soft, but rather tough, texture. A very slight tuft of flossy white silk is found inside, and within this the eggs are deposited. In one cocoon of a string of thirteen, twenty-five minute dead spiders were counted, which had passed their first moult. In another cocoon, taken from a string of five only, there were twenty-six. The number varies a good deal, however. The cocooning period appears to extend into May; at least I have received from Miss Anna Wittfeld, as late as the middle of June, a string, in which were

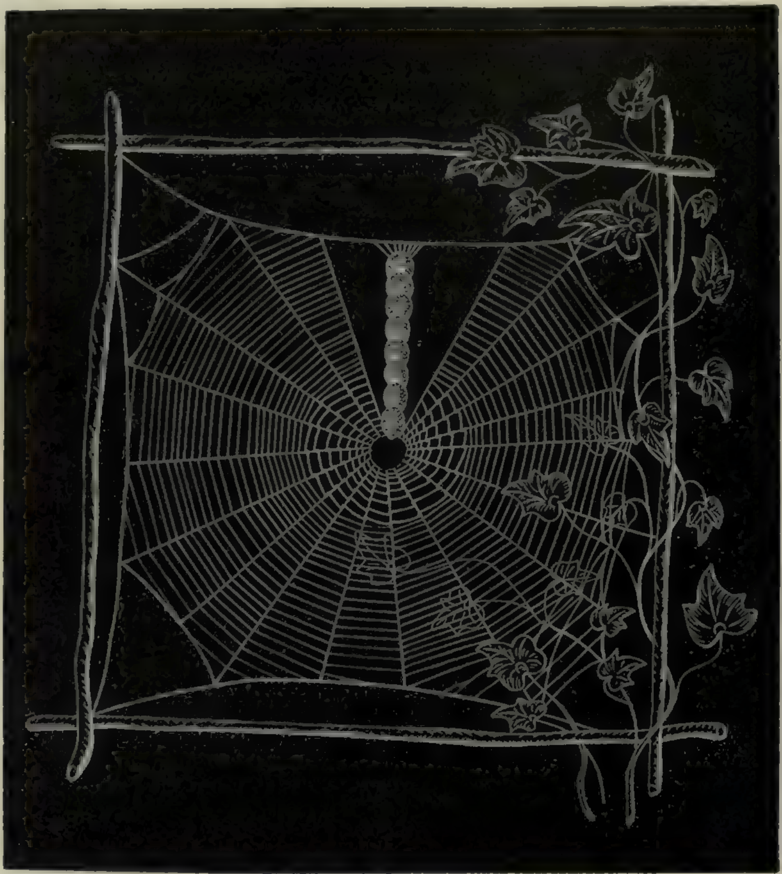


FIG. 97. Snare and cocoon string of Epeira bifurca, to show the manner of suspension.[1]

[1] The shape of the cocoons is not well represented in the cut. (See Fig. 96.)

some cocoons empty, one with spiderlings passed the first moult several days, and another with young who had just broken the egg. There was no trace of the bifurcated abdomen upon these younglings. The spider is of a uniform light green color, about the shade of its cocoon.

Another Orbweaver that makes several cocoons is Epeira basilica. I am indebted to Dr. George Marx, of Washington, for the specimens from which the following studies and drawings have been made, as well as for the information concerning Basilica's habit of caring for her eggs. The number of cocoons is five, thus corresponding with that of Labyrinthea, and generally with Caudata. They are round, covered on the outside with gray spinningwork, and united by a cordage so stiff that the series stands out like a stick. They are attached to a triangular patch of yellowish white silk, which is an expansion of a long, glossy, strong linen like cord, composed of many threads, by which the string of egg balls is suspended. (Fig. 98.)

Cocoon of Basilica Spider.

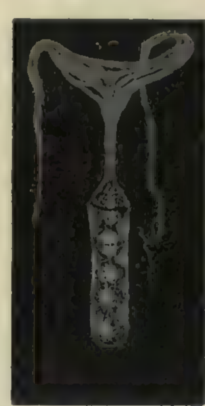


FIG. 98. Cocoon string and suspension cord of Basilica spider.

According to Dr. Marx, whose observations were made at Washington, the string is hung just above the centre of Basilica's peculiar domed snare, and wholly or in part within the dome, as represented at Fig. 99. The mother has position beneath her egg bags, back downward, as is the habit of Orbweavers making horizontal snares.[1]

When the cocoon is dissected, it is found to consist, first, of an exterior sac of gray material; within this is next enclosed a round black case (Fig. 100), four or five millimetres in diameter, having a thin shell of remarkable hardness, in this respect resembling the cocoon of Cornigera. When illuminated and examined under the microscope this egg ball is seen to be composed of yellow silken fibre of exceeding fineness, and so closely woven that, looked at when within its bag, it is quite black. The paper like stiffness of the ball could hardly be caused by even such fine spinning, and I believe that the fibres are smeared with a viscid secretion, which gives them their peculiar stiffness. When this black case is cut open it is seen to contain flossy silk (Fig. 101), which forms the customary wrapping of the eggs and nest of the young spiders.

Cocoon.

The cocoon of Uloborus is about one-fourth inch long, and one-eighth thick. It is drawn out at either pole into a point, and the surface is covered with small pointed or blunted processes. (Fig. 102.) It is made of a pure white silk, quite stiff of texture. Several of these cocoons (I have never found more than three) will be found united together so closely that they appear to be but one object, and not strung

[1] See for further details Vol. I., Chapter IX., especially page 170, Fig. 159.

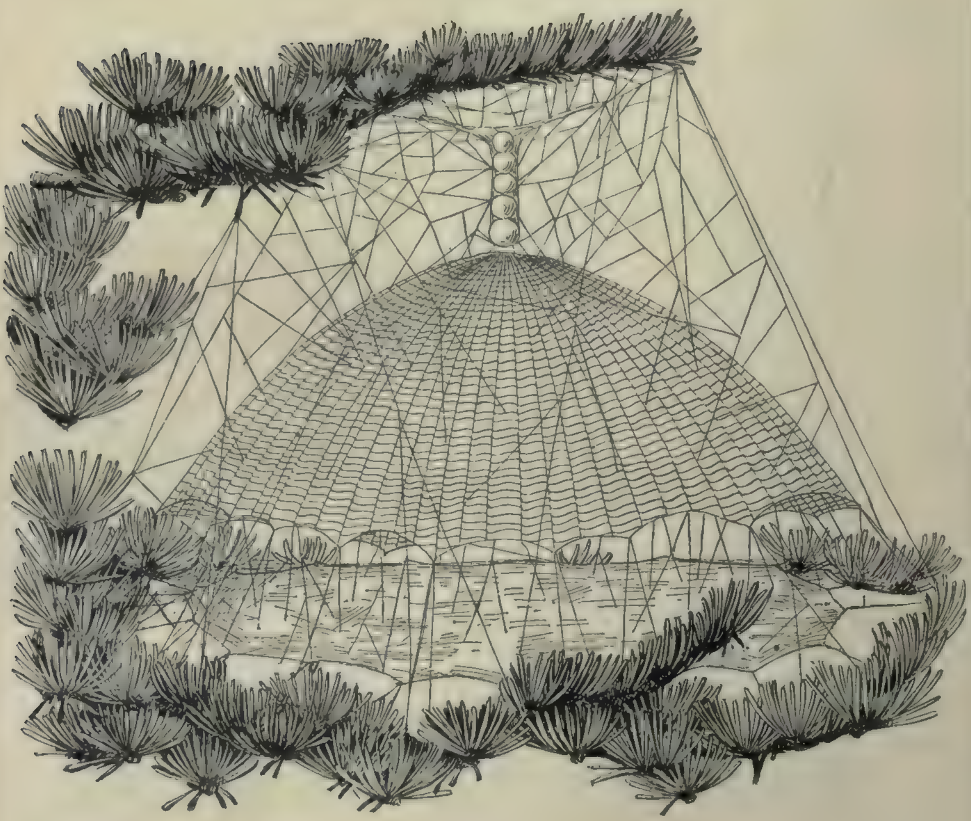


Fig. 99. Dome shaped snare and suspended cocoon string of the Basilica spider.

loosely, by attaching threads, as is the case of some other spiders that make several cocoons. However, in this respect, the habit may differ. As a rule these cocoons are stretched like those of Cyclosa caudata, along the axis of the mother's horizontal orb, and are thus immediately under the maternal care. (Fig. 103.) In this position I have seen them in New Jersey, and thus Mrs. Treat has observed them, and so also Mr. Emerton has described them. (Fig. 104.) Our American species appears in this respect to have the same habit as the European species, Uloborus walckenaërius.

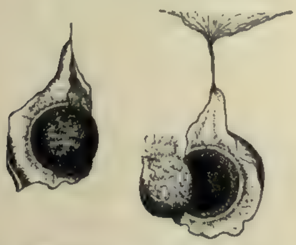


FIG. 100. FIG. 101.
Cocoon of Basilica spider: FIG. 100, the case open to show the black egg ball; FIG. 101, the ball open to show the inside structure.

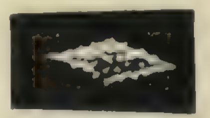


FIG. 102. Cocoon of Uloborus, enlarged to show the surface points.

This mode of disposing of the cocoon, however, cannot be universal, for I possess a specimen, received from Dr. George Marx, which is stretched along a little twig, to which its orb was attached, at a point slightly above the cocoon string. (Fig. 105.)

Hentz describes the cocoon of Uloborus mammeatus as tapering at both ends, in color whitish, with veins of brownish black, and with many small tubercles. He collected it in Alabama in dry places.[1]

VI.

The division here indicated between species habitually making a single cocoon and species habitually spinning several is, on the whole, a natural one; but there are certain facts to be noted which throw a measure of uncertainty around any such generalization. For example, it has long been supposed that Argiope cophinaria spins but one cocoon; and, judging from

FIG. 103. Cocoon string of Uloborus in position upon the snare.

[1] "Spiders of the United States," page 129, plate xix., Fig. 126.

its size and the number of eggs that are found therein, one would seem to be sufficient to guarantee the continuance of the species. I have no doubt that, as a general rule, Cophinaria makes but one cocoon, but that there are exceptions is very certain.

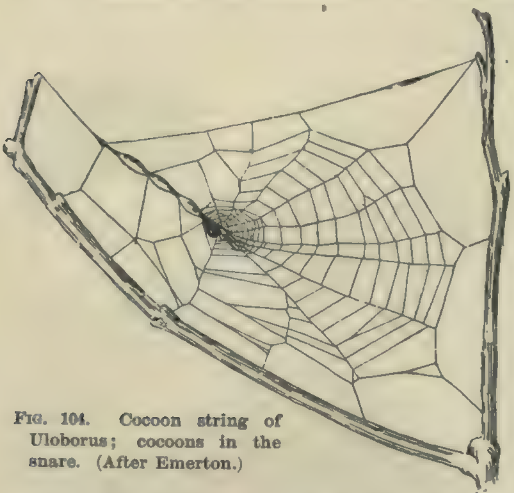


FIG. 104. Cocoon string of Uloborus; cocoons in the snare. (After Emerton.)

Several years ago a clerical friend brought me two cocoons of this species, which had been spun on his premises by the same spider. Mrs. Mary Treat has discovered what appears to her to be a variety of Argiope cophinaria, which makes four cocoons, and which she accordingly named Argiope multiconcha.[1] She sent me a string of these cocoons, of which there were four, of the general shape and about the usual size, strung within a few inches of each other. They had been spun against the wall of a kitchen in a house in Western Missouri. The spider mother was also sent, but the specimen was much dried up, and in such a condition that it could not be very satisfactorily studied. It seemed to differ in no particular from Argiope cophinaria. If it be indeed the same species, what are the peculiar circumstances that have caused such a remarkable variation in habit? Is it true that Cophinaria does, more frequently than has been supposed, indulge in the luxury of an additional egg case? Two cocoons of this lot were opened and found to contain young spiders that had hatched, but died within the egg sac. The spiderlings were not counted, but they were very numerous.

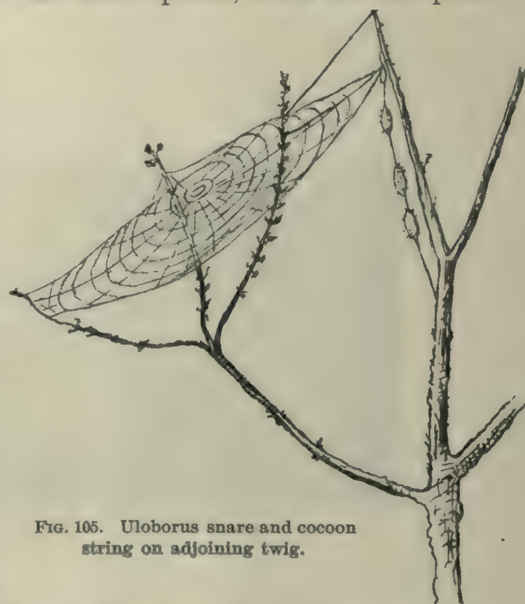


FIG. 105. Uloborus snare and cocoon string on adjoining twig.

Double Cocooning Argiope.

During the summer of 1888 a female Cophinaria was discovered in the Farmers' Market of Philadelphia upon the meat stall of one of the butchers. She had probably been brought into the market from the country, hid-

[1] "American Naturalist," December, 1887, page 1122.

den among vegetable leaves, as the huge tarantula and the large Laterigrade spider, Heterapoda venatoria, are brought to our port from the West Indies in bunches of bananas and other fruit. Or, she may have floated in, as a young balloonist, from some city garden; for the species is abundant in open grounds within the city limits. Instead of brushing her down and killing her, after the usual manner of dealing with such creatures, the farmer took a fancy to preserve her, and would allow no one around his stall to inflict any injury upon her. She wove her characteristic web against one of the iron rods for suspending meat, chickens, game, etc., and there remained secure during the season.

Some time between the 10th and 20th of August she began to make a cocoon, which she enclosed within a little tent of interlacing lines, after the manner of that represented at Fig. 40. About a week or ten days thereafter she made a second cocoon, placing it in a position sixteen inches above the other. Both of these cocoons I saw precisely as they were left by the spider. They were spun within tents of crossed lines, five or six inches long and four or five wide, with a thickness of between two and three inches. The lines constituting the under edges of the tent were attached to the post of the stall on which the orb was spun. The upper tent had its roof lines sustained and drawn out from the post by the foundation lines of the orb. (Fig. 106.) The lines composing the tents were of a greenish yellow silk, similar to that used in the construction of the cocoon cases.

FIG. 106. Double cocoons of Argiope, hung in a meat stall.

I removed the cocoons and opened them. The lower one was an inch and a quarter long and seven-eighths of an inch wide; was composed of a soft, yellow silken plush, and inside was constructed precisely like the ordinary egg sac of this species. It contained one hundred and twenty eggs, all of them sterile. The only peculiarity was that the stem which one usually finds at the top was missing. The second cocoon was not quite so large, one inch long and five-eighths of an inch wide, but was more perfect in shape, containing the usual stem. The eggs within this cocoon were also sterile, and the number did not exceed fifty. The number of eggs in both cases is small as compared with the usual fecundity of the species.

We may probably account for the making of the second cocoon by some abnormal condition of the ovaries, which prevented the ovipositing

of all the eggs at once. The first lot, when extruded, were protected in the usual manner. Subsequently Nature compelled the mother to get rid of the remaining eggs; and, moved by the same impulse which covered the first lot, she was excited to overspin the second also.

This species will sometimes make a cocoon, or a part of one, in confinement, and I have observed that she will occasionally do the same in natural site. I have the branch of a bush which shows the beginning of a cocoon, being the little cup against which the eggs are spun, and also what appears to be the inner egg bag. There is nothing more, and the whole is stayed and shut in by the usual tent like spinningwork. Near by is a perfect cocoon, secured in quite the same manner. If we suppose that these two were made by the same spider, as is highly probable, we may infer that the original cocooning purpose of the mother was diverted in some manner, perhaps by alarm, which drove her from the spot. She returned to enclose the work partially done, but, moved by the urgency of motherhood, presently found a neighboring site, and finished her maternal duties.

Epeira diademata habitually spins but one cocoon; but the Spanish investigator, Termeyer,[1] in the early part of this century, discovered and announced that she would spin as many as six cocoons when specially nourished. The fact strikes me as an extraordinary one, and I have never felt quite free to fully admit it.

[1] Walckenaer's Aptères, Vol. I., page 152.

CHAPTER V.

GENERAL COCOONING HABITS OF SPIDERS.

HAVING considered in detail the structure of the cocoons of Orbweavers, it is important for the sake of comparison that we should also consider some of the typical cocoons of other tribes. It will not be practicable to enter into details as fully as with the Orbweavers, nor to consider as many species in any of the remaining tribes. But I will give a few examples, under each tribe, of those species whose cocooning habits may be considered typical.[1]

I.

Theridium tepidariorum is one of our best known Lineweavers. It appears to be a native of America, and has been widely distributed by immigration throughout Europe. I judge that the course of immigration has been eastward, because in Europe the species is found almost exclusively in hot houses, both in England and on the continent, while in America it habitually lives in fields, forests, ravines, among rocks, around outhouses, indeed everywhere that a cobweb can be located. In short, in Europe the conditions of its life are artificial, in America natural. It is a ferocious species and an expert trapper, preying upon some of the largest insects. It spins during the season from three to five ovoid cocoons, often sharply pointed at one end, varying somewhat in size, but sometimes at least a third of an inch in the longest diameter. These are woven within the retitelarian snare of the creature, and suspended well towards the top.

Theridium tepidariorum.

Blackwall's figure of the manner in which the cocoons are suspended is erroneous, or the English spiders must differ in habit from the American. I have never seen any such sheeted, bell shaped tent as that which this author represents as enclosing the cocoons.

The cocoon is rather simple in structure, consisting of an outer case of yellowish brown material, well compacted, stiff, within which the eggs are loosely placed without any or with but little interior padding. During the weaving process the cocoon is hung by a strong thread, or series of threads, to the cross lines of the snare. The spider

Cocoon Weaving.

[1] My systematic knowledge of the other tribes is far less than of Orbweavers, and I have sometimes had difficulty in positively identifying the species whose habits I have observed. But I hope that I have not erred in many cases; certainly not in enough to materially affect my statements and conclusions.

clings to her web by one long fore leg, while with other legs she revolves her cocoon, using the hind legs, as is customary, to draw out the spinning stuff. This issues in numerous diverging filaments, which bunch up in minute loops as the abdomen descends, and are beaten down smooth by the spinnerets.

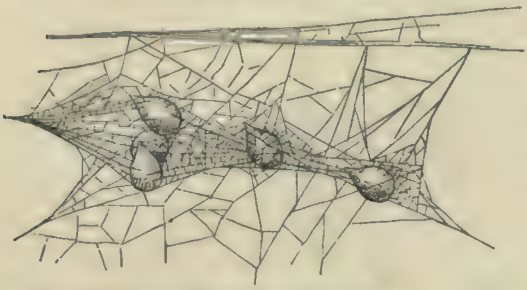


FIG. 107. Cocoons of Theridium tepidariorum, hung in her snare. (About natural size.)

Our widely distributed Latrodectus mactans[1] quite resembles Tepidariorum in cocooning habit; but its ovoid cocoons are larger, being a full half inch at the longer axis, and somewhat more spherical in shape. She makes at least as many as four or five cocoons.

Theridium differens.

Theridium serpentinum Hentz[2] is one of our common Lineweaving spiders, whose snares are found in dimly lighted cellars and in rooms abandoned or rarely used. In the angle of a window or wall the mother spreads her snare of intersecting lines, and establishes herself at one end thereof, always well towards the top. In the course of time she succeeds in thickening her dwelling place by added threads, until it has formed a sort of shelter of lines much more closely set than those of the rest of the snare. In the neighborhood of this dwelling place and on a line therewith, or just a little above it and to one side, she spins several cocoons, in number four or five usually, but sometimes as many as eight, as shown in the figure. (Fig. 108.) They are little white, oblong or flask shaped flossy balls, about quarter of an inch in diameter, in the centre of which the eggs are deposited. In the delicateness and scantiness of the enveloping tissue, this cocoon resembles Steatoda borealis and Pholcus phalangioides. The eggs are distinctly seen through the silken envelope. When the spiders are hatched they hang for a little while in clusters like minute swarms of

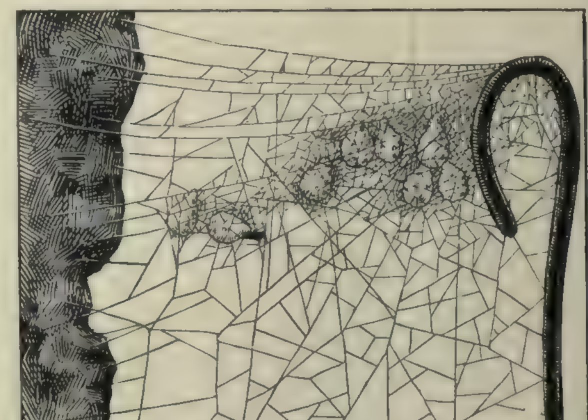


FIG. 108. Cocoons of Theridium serpentinum in site at top of her snare. (Natural size.)

[1] Lathrodectus formidabilis Walck. See also Vol. I., page 274.

[2] I am not positive as to the identity of this species.

bees upon the adjoining lines, and soon thereafter distribute themselves, as is the custom with Theridioids generally, to surrounding points, where they construct webs like the mother's.

Another Theridioid spider, whose specific name is unknown to me, spins a similar snare in like localities, and deposits therein several eggs, almost resembling those of Serpentinum, except that they are of a yellowish brown color and more spherical in shape. They have a pretty appearance as they hang amidst the crossed lines in the dusty and dusky sites which the mother frequents.

Among Lineweavers making several cocoons is Argyrodes trigonum. The species belongs to a genus quite famous for its habit of invading the snares of other species, particularly those belonging to its own tribe of Retitelariæ, and those Orbweavers that make compound snares and thus afford a suitable dwelling place in the labyrinth or maze of crossed lines. I have observed this habit in Trigonum, but have more frequently found it in its own snare. It is an awkwardly shaped creature, and its odd appearance is increased by its habit of bunching its legs together, and hanging upon a few crossed lines in its snare, as represented at Fig. 109. In this position it looks not unlike a trussed fowl in a green grocer's stall.

Argyrodes trigonum.

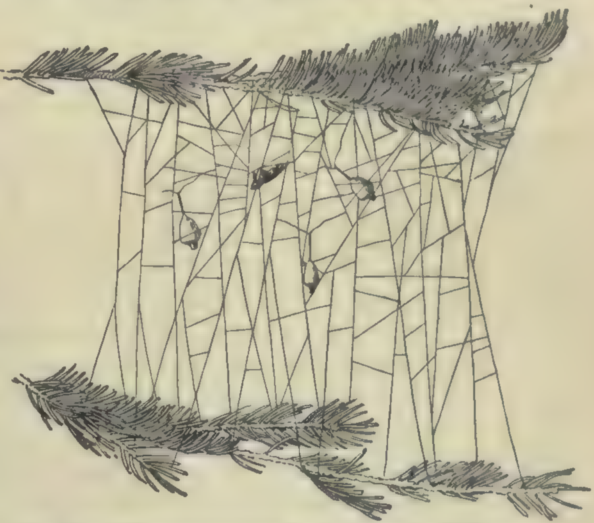


Fig. 109. Argyrodes trigonum in her snare, with three cocoons. (Natural size.)

Her cocoon is a pretty pyriform hanging basket, about one-fourth inch in length and one-eighth in thickness, composed of stiff yellowish brown silk. The upper part is a cone, rounded or tapering well to a point, at which is attached a stiff white cord, by which it is fastened into its place among the crossed lines of the snare. The lower part of the basket terminates in a short projection from the middle. (Fig. 110.) The mother makes several cocoons; I have found as many as three (Fig. 109) hanging within a snare at one time, all of which were doubtless made by the little mother. The cocoons are suspended by long, stout cords. When this hanging basket cocoon is opened the eggs are seen loosely deposited in the midst of a little puff of flossy silk. I sometimes find at the bottom of the cocoon a little hole, through which evidently the young have escaped after hatching.

Ero thoracica.

Ero thoracica, a spider common to Europe and America, weaves a small flossy cocoon, containing about twelve eggs, which it suspends to various objects, grass, twigs, etc., by a long thread. (See Fig. 111.) Emerton has found this spider in New England; it is common in winter under leaves; he has also seen cocoons like those of the European Ero as above described, but has not identified them with the American species, whose web he has not seen.

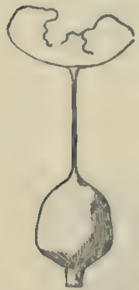


FIG. 110. Cocoon of Argyrodes trigonum. ×2.

Something similar to this, but a little more complicated in structure, is the pretty orange brown cocoon of Theridium frondeum, which is found suspended ordinarily to a stretched, stiffened cord among rocks or leaves. It appears particularly to love shady positions; at all events, I have found it most frequently among rocks on banks of streams, in ravines, or moist and secluded spots, as far west as the hills of Eastern Ohio. It is about an eighth of an inch long, but varies somewhat in length.

Cocoon Structure

On opening this pretty little cocoon of Theridium frondeum, it is found to be filled with a delicate white silken floss, in the midst of which the eggs are deposited and the young will be found after hatching. The number of eggs appears to differ a good deal. I have counted as many as twenty-five in one cocoon, but many less than this in others. The flossy padding is compacted well towards the top of the cocoon, and passes out of a round opening therein in the shape of a carded cord of straight lines of white silk, which gradually diminishes until it is compacted into the stiff white cord by which the whole is suspended. A curious arrangement is shown in the enlarged figure of a dissected cocoon (Fig. 113), which is used by the spider as a cap to the open top of her cocoon. In other words, the cocoon, instead of being a continuous piece of spinningwork gradually tapering into a point, as it appears at the first careless glance, proves to be composed of two pieces. First is the principal part or sac, which has already been referred to as having a round opening at the summit. Fitted directly upon this, but easily separated from it by pulling, is a conical cap, which surrounds the lower part of the suspensory cord already described. This cap, by manipulation under the microscope, can be unraveled so that it is seen to have been formed by lapping the yellowish cocooning thread, of which the main sac has been woven, around and around the base of the suspensory cord, after that has been spun. (See Fig. 114.) The whole cocoon forms a very beautiful and delicate bit of spinningwork, and shows considerable deftness in weaving on the part of its little architect.

FIG. 111. Cocoon of Ero thoracica, slightly enlarged. (After Cambridge.)

Somewhat similar to this is the cocoon of Ero variegata (Theridium

FIG. 112. FIG. 113.

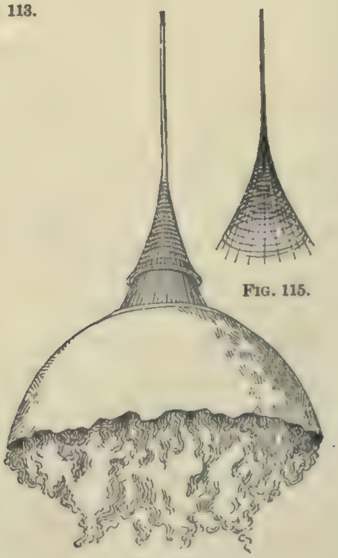


FIG. 115.

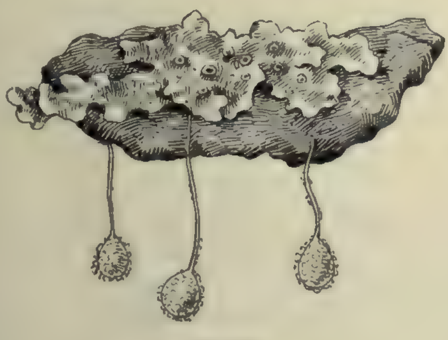


FIG. 116.

FIG. 114.

FIG. 112. Cocoon of Theridium frondeum, magnified. FIG. 113. The same, natural size, suspended in natural site. FIG. 114. Cocoon of Argyrodes trigonum, much enlarged, to show the structure. FIG. 115. The spiral thread on the cap and stalk. FIG. 116. Cocoons of Ero variegata, twice natural size. (After Blackwall.)

variegatum), a little spider not uncommon in England, which would arrest the attention of even an indifferent person. It is of an elegant pear shape, formed of a strong yellow brown silk network, and attached by a long elastic stem of the same material to stalks of dead grass, sticks, or other substances in shady places.[1] It is often placed on the under side of rocks, stones, etc. The envelope is double, an inner sac being formed of soft pale brown silk, loosely woven and enclosed in a coarse covering of dark reddish brown threads, which unite and form the stalk. The diameter of the cocoon is about one-eighth inch, and the length of the stalk is from one-tenth to one-half an inch. The cocoon contains about six brown eggs. The mother is one-eighth inch long.[2]

Ero variegata

Theridium pallens is a small English Lineweaver, about one-tenth of an inch long, that makes a cocoon a little longer than herself, containing about twenty pale yellow eggs. It is white, of a close, fine texture, and somewhat pear shaped; with several conical prominences disposed in a circle around its greatest circumference. (Fig. 117.) The sexes pair in May; the cocoon is formed in June, and is found on shrubs and bushes, on heaths or near woods.[3]

Theridium pallens.

A Lineweaver which I find in our fields, and which I take to be Theridium differens (Fig. 118) makes a globular cocoon, about one-eighth inch in diameter, a little larger than herself, which she hangs within her snare of crossed lines that may often be found spun in the interspaces formed by bending down the top and edges of a leaf. The cocoon is rather flossy in its exterior. The cocoon of the same species, or one closely resembling it, I find within the concavity of a leaf, formed by pulling the pointed ends inward, as at Fig. 119. The hollow is overspun with intersecting lines which form the spider's snare and dwelling, and the lodging place for her egg sac. The little mother is usually found near her cocoon, which she often clasps with her legs, especially at any suspicion of danger. She is apt to lug it about from point to point within the leafy bivouac thus prepared.

FIG. 117. Cocoon of Theridium pallens. × 4. (After Cambridge.)

A similar cocoon made by a Theridioid spider which I am unable to identify is represented at Fig. 120. The cocoon was a globular one, resembling in appearance the last two described, but was hidden underneath a stone within a little nest of characteristic spinningwork, but which on one side was protected by a semicircular wall of clay, mingled with silk and attached to the under surface of the stone. In this respect, the cocoon and cocoon nest resemble that of Neriene rufipes and others of this genus as described by European writers.

Theridium lineatum Clerck is found among our American fauna, Emerton[4] having taken it in Massachusetts. It is common in Europe; its cocoon

[1] Cambridge. [2] Staveley, "British Spiders," page 156.
[3] Blackwall, "Spiders of Great Britain," page 195. [4] New England Theridiidæ, page 16.

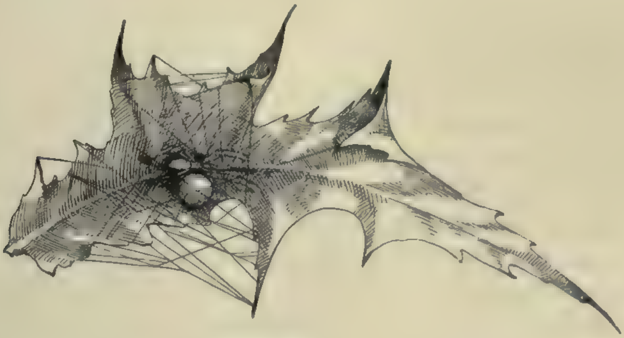


FIG. 119.

FIG. 118.

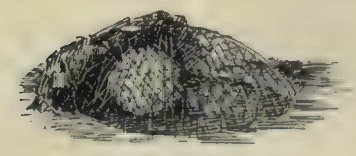


FIG. 120.

FIG. 121.

FIG. 122.

FIG. 118. Snare and cocoon of Theridium differens. FIG. 119. Cocoon of Theridium differens in a leafy tent. FIG. 120. Theridioid cocoon under a stone. FIG. 121. Cocoon of Theridium lineatum in natural site on a leaf. (After Blackwall.) FIG. 122. Theridium varians and cocoons. (After Blackwall.)

is formed in July and is round, one-fourth inch in diameter, and bluish or greenish blue in color. It is loosely covered with silk and fastened to the lower side of a leaf, the edges of which are bound together, so as to protect it.[1] (Fig. 121.)

Theridium varians. Theridium varians pairs in June, and in July the female constructs several globular cocoons of dull white silk, of a loose texture, the largest of which measures about one-seventh of an inch in diameter. They are attached to objects situated near the upper part of the snare, and contain, according to their size, from twenty to sixty spherical eggs, of a yellowish white color, not adherent among themselves.[2] (Fig. 122.) Withered leaves, dried moss, and particles of indurated earth are generally disposed about the cocoons.[3] This habit, which, as will be seen further on, prevails largely in other families, appears to have but slight hold upon the cocooning instincts of the Lineweavers.

Fig. 123. Cocoon of Erigone (?) suspended between twigs of pine.

The little bronze colored spiders belonging chiefly to the genus Erigone, weave their cocoons within the balled mass of intersecting lines which form their snare and abode. I have seen numberless examples of these webs, made manifest by the morning dews along the Delaware, shining over the entire external foliage of a large spruce tree from topmost to lowest bough. Again, they will be seen with other Theridioid webs, glittering in the slanting sunlight on myriads of bunched grass tops, timothy heads, and weed tops. Some species of Erigone make a little balled cocoon similar to those of Theridium first described, and similarly held within the snare. Another form of cocoon which I attribute to a spider of the same genus is a minute white button shaped or double convex bag, from one-sixteenth to one-eighth inch in diameter. **Erigone.** It is suspended at the converging points of four lines (Fig. 123), which are attached to the surrounding foliage, as in the example shown of a cocoon hung between two twigs of pine, near a Theridioid web, in which an Erigone was ensconced.

---

[1] Staveley, Brit. Spiders, page 140; Blackwall, Spi. Gt. B. & I., pl. xiii., Fig. 111.

[2] Two small round cocoons are seen within the tent like structure in the cut, but in this case, as with the figure of Theridium tepidariorum, as heretofore remarked, the artist has erred by drawing in a sheeted tent instead of a structure of open lines.

[3] Blackwall, Spiders Gt. B. & I., page 189, pl. xiv., Fig. 120, d.

Theridium zelotypum makes a flattened cocoon of soft silk, which she establishes within her pretty nest, that has heretofore been described (Vol. I., page 317) as a silken, bell shaped tent thatched with the leaves of spruce, balsam, hemlock, or other plant on which it is built. Within this the young are hatched, and here for a while after their exode mother and young may be found dwelling together.

Theridium zelotypum.

A like habit is possessed by the English nest making spider, Theridium riparium, whose most remarkable nesting architecture is described Vol. I., page 318. The mother makes several yellowish white, round cocoons about one-eighth inch in diameter.[1]

Theridium sisyphum also shelters her reddish brown cocoons in a silken tent which hangs in her snare, and is sometimes strengthened by the introduction of dried leaves and other extraneous matter.[2]

Another English spider, Theridium nervosum, also[3] forms a silk lined nesting tent, thatched with bits of dead leaves, flowers, or other particles, including the débris of slaughtered insects. Within this tent the mother spins a little round green cocoon, containing yellowish white eggs. The cocoon is one-eighth inch long, the spider herself being one-sixth inch. The mother is usually to be found in an inverted position, embracing her treasure and covering it with her body.

It is probable that all the nest weaving species of Retitelariæ place their cocoons within their nests, in which habit they substantially agree with their congeners, who suspend their cocoons upon the thickened cross lines which form the resident part of their snares.

I have never been able to determine satisfactorily from observation the cocoons of our common species of Linyphia, but the Linyphia montana of Europe makes a flattened white cocoon, which it usually conceals underneath a stone, remaining with it and guarding it with the greatest care.[4]

Linyphia.

Linyphia marginata, one of our most common American spiders, is also a European species.[5] It pairs in May, and in June the female spins one or two lenticular cocoons of white silk of a loose texture, which are attached to withered leaves or other objects situated near the snare. The larger of these cocoons measures half an inch in diameter and contains about one hundred and forty spherical eggs of a palish yellow color, not agglutinated.[6]

The English Linyphia crypticolens is remarkable for the habit of carrying her cocoon fastened by threads to her spinnerets. It is globular and of a diameter equal to the whole length of the mother, is formed in June

[1] Staveley, British Spiders, page 152. [2] Idem, page 143. [3] See Vol. I., page 317.

[4] Staveley, "British Spiders," page 165.

[5] Equal to L. montana Sund., L. resupina Walck.

[6] Blackwall, Spiders Gt. B. & I., page 215.

or July, is a pale brownish color, containing brown eggs. It resorts to dark and damp places, as cellars and the under surfaces of stones. It is certainly remarkable to find a Lineweaving species thus approximating the Citigrades, from which it so greatly differs in other respects, in the manner of caring for the cocoon.

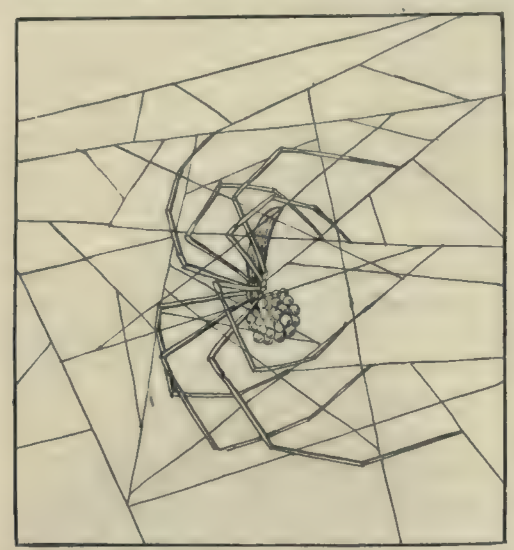


Fig. 124. The mother Pholcus hanging in her snare, with cocoon held in her jaws.

But in this habit she is not alone among her tribe. Theridium carolinum forms in June a round white cocoon one-tenth inch in diameter, which she carries attached by threads to her person.[1] A pretty little Theridioid, Steatoda maculata (Theridium maculatum Linn.), is also said to carry about its egg cocoon suspended between the legs, and only relinquishes it when force is used, regaining it quickly if possible.

Pholcus. The cocoon of Pholcus phalangioides, which is perhaps the very simplest in structure of all this tribe, and I may add of all the tribes, is simply a gauzy covering which encloses the eggs, the whole being gathered into a globular mass. This is held by the spider within her jaws as she hangs in her ordinary position within her straggling web of intersecting lines. In this portage of her egg case Pholcus approaches the habit of the Citigrades and Tunnelweavers. (Fig. 124.)

Fig. 125. English Pholcus phalangioides, with her cocoon. (After Blackwall.)

Scytodes thoracica Latr. (Scytodes cameratus Hentz) has been found by Mr. Emerton, in New England, as a house spider, which he supposes has been imported from Europe. European observers note that this spider carries her cocoon under her breastplate, in which position it is not secured by silken threads, but is held by the falces and palpi. In this habit it resembles Pholcus, with

[1] Staveley, "British Spiders," page 141.

which it is closely allied structurally. It is found in houses, upon walls, etc., in warm situations. It is described as slow and deliberate in its motions, displaying somewhat of the action of a gnat in lifting and poising its leg in the air when walking. The whole character of the aranead is mild and quiet. The poison fangs are so feeble as to be of but little use in seizing its prey, which office is chiefly performed by the maxillæ. When taken, Scytodes offers no resistance and attempts no flight, but, feigning death, resigns itself quietly to its fate.[1]

Scytodes thoracica.

This tribe embraces the singular genus Walckenaëra, some of whose species have the eyes placed upon little turret like elevations of the cephalothorax. Their habits have not been carefully studied, and their cocoons are little known. One European species, Walckenaëra acuminata, makes a cocoon flat on one side, rounded on the other, about one-third inch in diameter, and composed of slightly woven white silk. It is found in autumn on the under surface of stones and

Walckenaëra.

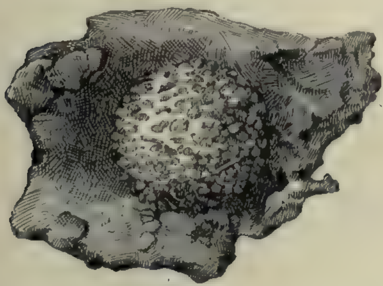


FIG. 126.

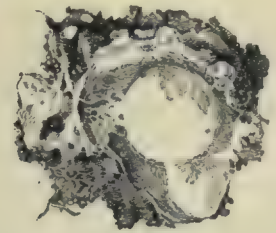


FIG. 127.

FIG. 128.

Cocoon of Agalena nævia, spun upon bark.

FIG. 126. Appearance of exterior, covered with brown sawdust. FIGS. 127 and 128. Views after the outer coverings have been removed.

other objects.[2] Our American fauna has a number of closely related representatives of this strange genus, which are relegated by Emerton to various genera,[3] and it is probable that their cocoonery nearly resembles that of the above species.

II.

The most common Tubeweaver in the Eastern States is probably the Speckled Agalena, Agalena nævia. Its funnel shaped nest, with its broad sheeted top spread over the grass or hedges, or stretched in miscellaneous sites, is one of the most familiar objects in our landscape. Its cocoon is attached to some surface, as the leaf of a tree, a rock, or the under surface of a loose bit of old bark. In this position Agalena spreads a circular patch a half inch or more in diameter, within which she encloses her eggs. This is covered

Tubeweaving Agaleninæ.

[1] Staveley, "British Spiders," page 268. [2] Idem, page 205.

[3] See his "New England Theridiidæ."

again with a thin sheet, upon which the mother overlays a wadding of sawdust or pulverized bark gnawed from the surrounding surface. In the absence of such materials, the upholstery consists of any available fibre furnished by the particular site. The whole is then overspun with an exterior covering. It is thus one of the most elaborate of known cocoons, and apparently is as well calculated to preserve the life concealed within as any spinningwork that could be wrought by aranead spinning organs.

Upholstering Omitted.

When Agalena cannot conveniently obtain sawdust and like material for the upholstery of her cocoon, she will overspin her eggs without such protection. For example, a female of this species was observed upon the window of a chicken house, with a pretty tubular snare hung against the frame, and two cocoons woven upon the glass near by. These were simply eggs of a pinkish hue, covered over with silken spinningwork and no upholstery added. I have also found Agalena's cocoon woven upon the under side of a leaf, in which position it contained no upholstery, and, indeed, quite resembled the cocoon of an Epeïroid spider spun in like situation. I suppose that in this case, as also in the preceding one, the difficulty of gnawing off the tough, green fibre of the leaf and branches, or of the painted wooden frame of the window was an obstacle which prevented the mother from pursuing her usual habit. Perhaps, indeed, it requires the suggestion of near by and available material, like that of bark or decayed wood, to induce this additional upholstering protection of the cocoon.

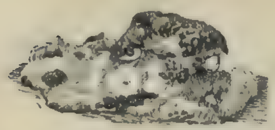


Fig. 129. Cocoon of Agalena nævia on loose bark, to show the mode of uniting to the opposite surface by a stalk.

On the other hand, a female of this species, which I kept within a glass jar, having made her cocoon, proceeded to collect from the bottom of the jar bits of débris of various sorts, which she placed upon it in the usual position. There were only a few of these particles, not enough to be of any value for the protection of the enclosed eggs, even if there had been any exposure to danger under the circumstances. Of course, it could hardly have been expected that this mother would understand that her offspring, by reason of the situation within a glass jar, would be safe from the enemies which usually assail the eggs of the species in natural site.

Sometimes the cocoon of this species, when spun upon a loose piece of bark, will have a thick stalk spun across to the opposite surface of the tree to which it is united by a circular patch of thick silk. (Fig. 129.) A like arrangement is found when the cocoon is woven up against the lower side of a stone, the exterior or under part being then carried downward by a stalk to the earth. This is not a common method, however, and I can think of no good reason for such a variation.

Agalena labyrinthea of Europe resembles in its general habits the Agalena nævia of America. According to Walckenaer the female makes her single cocoon in the month of August, which she encloses within a huge purse like web full of soil and vegetable detritus. When the web is removed, the cocoon is seen to be about the size of the end of one's thumb, and woven of a fine silken tissue enveloped by clods of earth. Next to these is another envelope of silk, and then, finally, particles of soil so strongly adhering to the cocoon that they cannot well be separated. When the cocoon is opened, it is found to be formed of a thick, tough web. On the exterior it is beautifully white and perfectly polished. It contains as high as one hundred and thirty-four eggs of a greenish yellow color.[1]

Agalena labyrinthea.

The well known cellar spider, Tegenaria derhamii,[2] which is widely

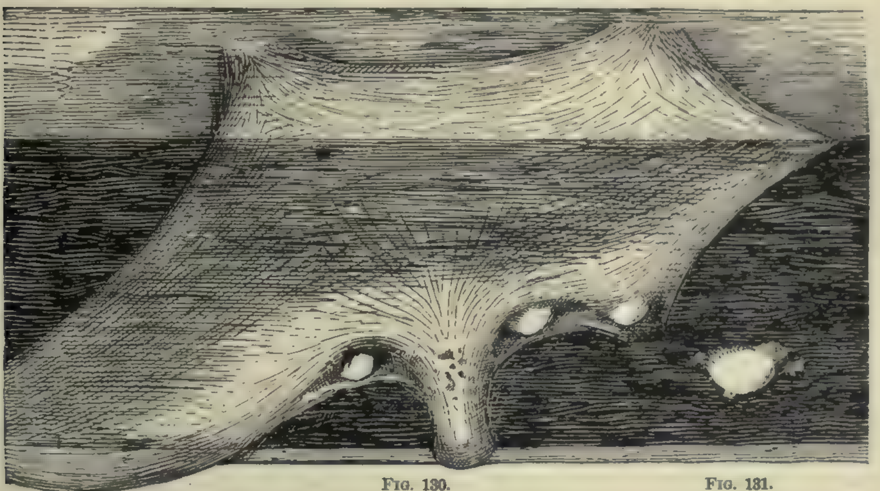


FIG. 130. FIG. 131.

FIG. 130. Snare of Tegenaria derhamii in a cellar window, with three cocoons suspended thereto.
FIG. 131. One cocoon, natural size.

distributed over both hemispheres, conceals her eggs within a flattened ball or hemisphere of soft silk, somewhere in the neighborhood of her snare. Sometimes this is suspended by threads to the snare itself (see Vol. I., page 239, Fig. 221), or again is attached directly to it, and the envelope interwoven with the fibre of the web, so that it has much the appearance of a rounded button upon a coat. Fig. 130

Tegenaria.

[1] Walckenaer, Aptères, Vol. II., page 22.

[2] I have supposed that the Medicinal spider of Hentz, Tegenaria medicinalis, is identical with this species, and have so used the name in Vol. I. Mr. Emerton, however, in a recent paper, declares Hentz's Tegenaria medicinalis to be a Cœlotes, and separate from T. derhamii. He classifies as Cœlotes medicinalis the spider that I have heretofore considered Hentz's Tegenaria persica. See Trans. Conn. Acad., Vol. VIII., 1889-90, New Eng. Spiders of the Families Drassidæ, etc.

represents the snare and cocoon of one of these spiders. The mother was hidden within a curtained screen or tower newly spun. On the beam just above the snare hung two cocoons. They were attached above and on the sides to the beam, and in front and on the sides to the flap of the snare. Their position was such that they were just above and in front of the door of the den. One of them was covered with black particles of dust. They were about half an inch in diameter. Figs. 132 and 133 are views of the manner in which the cocoons were suspended. One often finds these cocoons woven into the texture of abandoned snares in cellars and outhouses. Fig. 130 is a sketch of such a web hanging in a window of my church cellar. The pouch like snare stretched upward to the window roof, and at the bottom, on either side of the tube or tower, three button shaped cocoons were inserted. They were still white when sketched in midwinter, although the web was much soiled with the cellar dust and soot. I do not know that all three cocoons were made by one mother.

FIG. 132.

FIG. 133.

FIGS. 132, 133. Suspended cocoons of Tegenaria derhamii. (Natural size.)

Cœlotes medicinalis (Tegenaria persica Hentz) usually spins her cocoons on or near her snare. I have found in one snare two globular cocoons covered with bits of clay. One contained round whitish eggs; the other had living spiderlings with white cephalothorax and greenish abdomen.

Agrœca brunnea [1] is an English species. The sexes pair in May, and in the month of June the female constructs an elegant vase shaped cocoon of white silk, of a fine compact structure, attached by a short foot stalk to rushes, stems of grass, heath, or gorse. It measures about one-fourth inch in diameter, and contains from forty to fifty yellowish spherical eggs, enveloped in white silk, connected with the anterior surface of the cocoon, contiguous to the foot stalk. Greatly to the disadvantage of its appearance, the cocoon is smeared with moist soil, which when dried serves to protect it from the weather, and, as an additional security, the extremity is closed and directed downward.[2] In the illustration (Fig. 134) the uppermost cocoon is shown as it is first spun, the two lower cocoons as they appear when plastered. Another drawing (Fig. 135) of this beautiful cocoon, which has attracted the attention of all English araneologists, is taken from Rev. Pickard-Cambridge. With it is a similar cocoon of an English congener, Agrœca proxima (Fig. 136), woven like the former species upon a twig of heather.[3]

[1] Agalena brunnea Blckw. [2] Blackwall, Spid. Gt. B. & I., page 160, pl. xii., Fig. 102.
[3] Spiders of Dorset, Vol. I., pl. ii., Fig. 7.

Cœlotes and Textrix.

Cœlotes saxatilis makes a cocoon half an inch in diameter, containing yellowish white eggs. The external case is partly plastered with earth. (Fig. 137.) Textrix lycosina has the same habit of protecting her cocoon, which is usually woven to the under side of a stone near her tubular hiding place. It is white, flattened, and about one-fourth inch in diameter.[1]

Argyroneta aquatica.

According to the Swedish naturalist Clerck[2] the eggs of the Water spider, Argyroneta aquatica, are round, of a saffron yellow color, contained within a globular silken cocoon, which occupies about one-fourth of the subaqueous maternal cell. (Fig. 138.) The female remains constantly near it, keeping her abdomen in the interior of her habitation, and the fore part of her body in the water. The figures of this cocoon (Figs. 139 and 140) are from Blackwall,[3] and represent a hemispherical or disk like object resembling cocoons made by many terrestrial Tubeweavers, especially the Clubionidæ. Argyroneta's cocoon presents the appearance of having been woven against a flat, solid surface, or perhaps the silken walls of the cell. Other naturalists represent it as being swung like a hammock across the cell, somewhat in the fashion of the cocoons of various Tunnelweavers hereafter described.

Blackwall's description of the cocoon, its site, and preservation is as follows: Argyroneta aquatica habitually passes the greater part of its life in the water, not only pursuing its prey in that liquid, but constructing beneath its surface a drum shaped cell in which is placed its cocoon of white silk of a compact texture and lenticular form, containing from eighty to one hundred eggs of a yellow color, not agglutinated together. This is well supported in a vertical position, the open part being directed downwards by lines of silk connecting it with aquatic plants, and as it comprises a considerable quantity of atmospheric air, the spider can at all times occupy it without experiencing the least inconvenience. In swimming and diving Argyroneta assumes an inverted position, and is more or less enveloped in air confined by the circumambient water among the hairs with which it is clothed. The supply is always more abundant on the under than on the upper part, in consequence of the greater length and density of the hairs distributed over its surface.

Family Drassoidæ.

Passing into the large and varied family of Drassids, we find a substantial uniformity in the general shape and structure of their cocoons. These are usually lenticular or button shaped (plano convex) objects woven against some solid surface in the vicinity of the tubular nest or ordinary haunts of the species. The covering is a close textured silk, as stiff as parchment. The circular piece attached to the surface is of similar composition, and the eggs are

[1] Blackwall, Spid. Gt. B. & I., pl. xii., Fig. 109.
[2] Aran. Svecici., page 149.
[3] Sp. Gt. B. & I., pl. viii., Figs. 87 g, h.

Fig. 135.

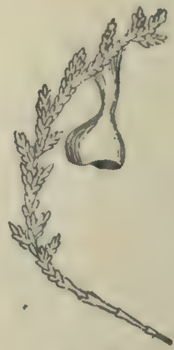
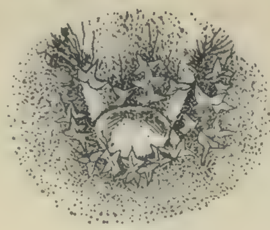


Fig. 136.

Fig. 134.



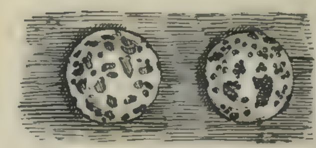


Fig. 137.

Fig. 138.

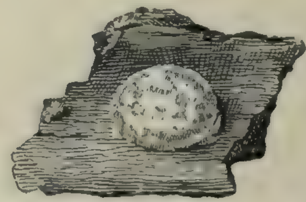


Fig. 139. Fig. 140. Fig. 143.

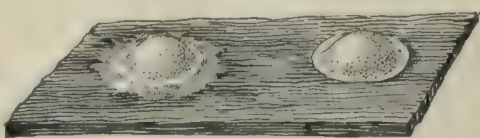


Fig. 142.

Fig. 141.

Fig. 134. Cocoons of Agalena brunnea, attached to moss. Slightly enlarged. (After Blackwall.) Fig. 135. Cocoon of Agrœca brunnea. Fig. 136. Cocoon of Agrœca proxima, attached to a sprig of heather. (After Cambridge.) Fig. 137. Cocoons of Cœlotes saxatilis, natural size, with particles of earth daubed on the surface. (After Blackwall.) Fig. 138. Subaqueous cocooning nest of the Water spider. (After Cuvier.) Fig. 139. Cocoon of Argyroneta aquatica, front view. Fig. 140. Side view. (After Blackwall.) Fig. 141. Two Drassid cocoons woven against a board. Fig. 142. One detached, to show the flat bottom. Fig. 143. Cocoon of Clubiona tranquilla (probably), woven upon bark.

commonly deposited inside, without any or with only a little flossy padding. The exterior is frequently plastered more or less freely with mud or the detritus of decayed wood.

Clubiona tranquilla makes a hemispherical or button shaped cocoon, which is attached to various surfaces, as of rocks, bark, or boards. (Fig. 143.) One female confined within a jar for observation spun her cocoon upon a little twig placed for her convenience within the vessel. As first completed by the mother the external covering was pure white silk. But, following her maternal instinct, she descended to the earth upon the bottom of the jar, collected pellets of mud between her mandibles, carried them up to her cocoon, and daubed the surface over in little ridges until the whole was quite mottled with the plastered mud. (Fig. 144.)

FIG. 144. Cocoon of Clubiona tranquilla, woven on a stick, and slightly mud plastered.

Sometimes the Drassid's cocoon is contained within the tubular domicile of the mother, and this again will be overspread with a tent of delicate texture, as in the case of the Parson spider, Prosthesima ecclesiastica (Herpyllus ecclesiasticus Hentz). (Fig. 145.)

The Parson Spider.

The Parson spider is a quite large species one half inch long, with a black body, marked along the thorax and dorsum of the abdomen with decided circular and oblong patches of white, to which peculiar markings it owes its specific name. Its habits are those of the Drassids generally, although it is not as sedentary as some others, but wanders in search of prey. It is commonly found upon trees, fences, etc., near some recess or opening into which it may retreat. Like some of our common house Theridioids, it is fond of taking refuge under the projecting parts of outhouses. In winter it is found wrapped in a thick sheeted tube of silk under the bark of trees and like situations. It is active in its movements, and prowls for its prey. It makes its cocoon early in June. This is composed of several layers of pure white silk, between one of which particles of dust are placed and quilted in with spinningwork. I have found the chippings of the carpenter bee among these particles.

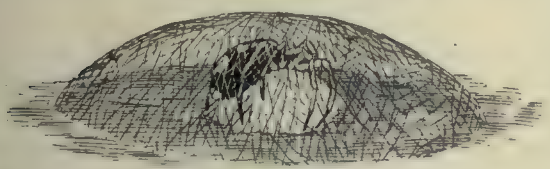


FIG. 145. The Parson spider brooding her cocoon within an enclosing tent.

An interesting and rather pretty little Tubeweaver, which appears to be Micaria aureata, the Herpyllus aureatus of Hentz, conceals its cocoon within a double tent. (Fig. 146.) The cocoon itself is a small, button shaped object, containing a few brownish yellow eggs. The example illustrated in the figure was spun within the angle of a wall, and covered over with a tube such as the spider usually spins for a dwelling place. Openings were

left at either end of this tube. Above the whole, and quite encompassing it, was woven a large tent several times the size of the first tube, and composed of spinningwork whose threads were quite closely placed, but of so thin tissue that one could see through it without any difficulty. A large opening appeared at one end of this external tent, but whether it was left of purpose for a door, or, more probably, was the result of accident, I could not determine.

Among the Drassids which I have found in Colorado is a species of Gnaphosa, which I took under a stone on the summit of the Snowy Range. It was dwelling in a little tubular nest. This species, according to Emerton,[1] is found all over New England, from the White Mountains to New Haven. Professor Packard found a female with a cocoon of eggs on Gray's Peak, Colorado, over eleven thousand feet

Gnaphosa.

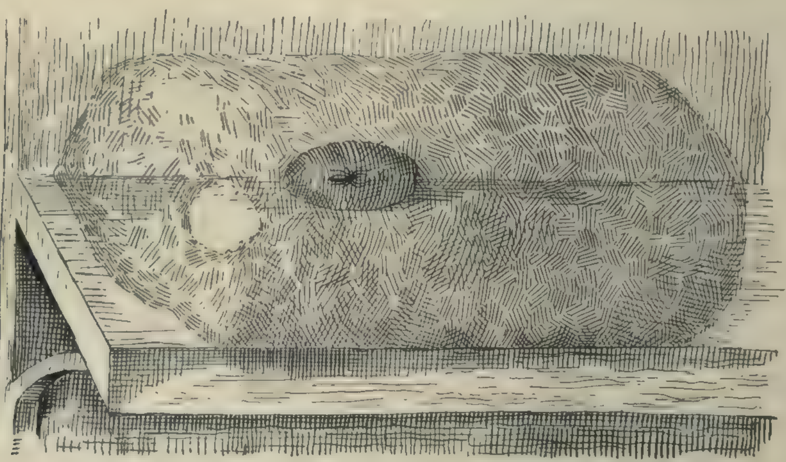


Fig. 146. Cocoon of Micaria aureata within an interior and exterior tent.

high. It thus has a remarkably great geographical as well as vertical distribution. The spider lives under stones and leaves. The cocoon is white and flat, with its diameter as great as, or greater than, the length of the spider. Emerton says that the female stays near her cocoon, but makes no nest. I would have expected her to make her cocoon within her cell.

Some of the Drassids, like the Agalenads, protect their cocoons by completely enclosing them in cases of mortar. Among these is a species sent me for determination by Mr. F. M. Webster, assistant entomologist of the State of Illinois, through whose intelligent interest the remarkable facts concerning this spider have thus been made known. Mr. Webster has found these mud cocoons throughout the whole range of Illinois, a State of great longitudinal extent. Two balls from Southern Illinois are larger than the others, and composed of

Mud Encased Cocoons.

[1] New Eng. Drassidæ, Trans. Conn. Acad., Vol. VIII., page 13.

MIMICRY OF ENVIRONMENT. TRAPDOOR SPIDERS.

1, BURROW WITH DOOR OF DRY OLIVE LEAVES, CLOSED. 2, THE SAME, OPEN.
3, 4, 5, TRAPDOOR COVERED WITH MOSS.

[illegible] and quite encompassing [illegible] the first tube, and [illegible] closely placed, but of [illegible] any difficulty. A [illegible] tent, but whether it [illegible] was the result of acci-[illegible]

[illegible] is a species of [illegible] of the Snowy Range. [illegible] species, according [illegible] from the White [illegible] Packard found a female [illegible] eleven thousand feet

[illegible]

[illegible] as well as vertical dis-[illegible]. The cocoon is white [illegible] the length of the [illegible] over her cocoon, but makes [illegible] within her cell.

[illegible] protect their cocoons by com-[illegible] is a species sent [illegible] assistant entomolo-[illegible] whose intelligent interest [illegible] spider have thus been made [illegible] throughout [illegible] extent. Two [illegible] and composed of

[illegible]

PLATE II.

MIMICRY OF ENVIRONMENT. TRAPDOOR SPIDERS.

1, Burrow with door of dry olive leaves, closed. 2, The same, open.
3, 4, 5, Trapdoor covered with moss.

yellowish earth or clay; but balls from Central Illinois are made out of the rich black soil common to the prairies. They vary in diameter from one-half to one-fourth of an inch. (Figs. 147, 148.) From most of them a slight silken cord protrudes (Figs. 147, 148, 153, 154), by which they are often found attached to the under side of a board or stone. The cord is sometimes thickened into a cup shaped patch at the point of attachment, and is occasionally composed of several threads. When these mud balls are softened in water one is able to open them, and in some cases the mud peels off in little layers like the skin of an onion, indicating that the method of structure is to plaster a thin coating of mud upon the entire cocoon, and add successive layers, which likewise cover the whole surface before another layer is begun. It is evident that no little mechanical skill is involved in such even distribution of the mortar.

The Cocoon Structure

In the centre of the mud ball is found a cocoon of delicate structure and pure white color (Figs. 151, 152), within which a few eggs are deposited. This can be lifted out of its matrix, leaving the round concavity smooth and well defined, as shown at Figs. 149, 150. The stock of the cocoon is carried at one point entirely through the mud ball, and issues at the surface in a thin cord whose use has been alluded to above. This stalk or suspensory cord is, of course, spun before the plastering begins, and is covered over gradually, an act which must require delicate manipulation.

By keeping some of the cocoons in a moist condition, I was able to hatch from one, May 30th, a brood of about thirty lively young Drassid spiderlings. They apparently belong to the genus Micaria, and I therefore named the species Micaria limicunæ,[1] although with much hesitation, as it is difficult to determine species from young spiders.

These mud balls in external form closely resemble the spherical mud egg nest of the wasp Eumenes, which I have often found attached to the stalks of weeds, grasses, etc., in the neighborhood of Philadelphia. (Fig. 156.) It is certainly interesting to observe that this habit of concealing the future progeny within a globular cradle of mud belongs to a spider as well as to a wasp, and to note how maternal solicitude finds expression in like forms among widely separated orders.

Limicunæ's Parasites.

Limicunæ appears to be much subject to the attacks of hymenopterous parasites. Mr. Webster found parasitic ichneumon flies in some of his boxes, which had evidently crawled out of one of the mud balls. Some of the balls seen by him had openings in the side about one millimetre in diameter (Fig. 148), from which evidently the ichneumon had escaped, since it contained the stiff white silken case commonly spun by the larva of this insect. I secured from one of my specimens, in the process of hatching the spiderlings, two of

[1] Proceedings Acad. Nat. Sci., Philadelphia, 1884, page 153.

Mud plastered cocoons of Drassid spiders.

FIGS. 147-152. Micaria limicunæ. × 2. FIGS. 153-155. Unknown species from Alexandria Bay. × 2.
FIG. 156. Mud nest of a wasp Eumenes.

these flies, which were determined by the eminent hymenopterist, Mr. Ezra T. Cresson, to be Pezomachus meabilis Cresson.

A Conglomerate Cocoon Ball.

I collected cocoons somewhat similar to those of Limicunæ near Alexandria Bay, New York, on the St. Lawrence River. They were attached by very loose spinningwork to the under side of stones, but the external case, instead of being mud, was a mass of agglomerated particles of old wood, bark, leaves, blossoms, shells and wings of insects, etc., which were held together by a delicate weft of threads. (Figs. 153, 154, 157.)

Two of these balls contained whitish cocoons similar to those in the mud balls of Limicunæ. (Fig. 155.) Another had within it the characteristic cases of some hymenopterous insect, containing dried pupæ. A very thin veneering of soil immediately enclosed the silken egg pouch, but otherwise no mud plaster was used. I did not succeed in hatching spiders from the specimens, and could not therefore determine that these cocoons were made by the same spider that constructs the mud balls of Illinois, but I am inclined to think they were made by the same or a closely related species.[1]

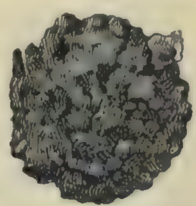


Fig. 157. Globular cocoon of Micaria, armored with chippings, soil, etc. × 2.

The Habit Catholic.

This habit of protecting cocoons with an armor of mud and agglutinated rubbish of divers kinds, is widely spread, and is, no doubt, quite cosmopolitan. It is possessed by several of the European species. Tegenaria agrestis is found under rocks, in which position the mother attaches her large cocoon, about half an inch in diameter, formed of a triple or quadruple envelope. The first are thin, white, containing a layer of sand and the débris of insects agglutinated together, followed by a third envelope of beautiful orange red, which contains a loose wad, a little compacted where the eggs are. The mother makes several cocoons, which she abandons and leaves isolated, or which she encloses under a single web, fine and transparent. In France these cocoons are found in July and August, chiefly in woods.[2]

The cocoon of Tegenaria emaciata, as described by Walckenaer, is formed of a round mass larger than a good sized pea. This mass is composed of soil agglutinated and mingled with the detritus of the bodies of small insects, as beetles, ants, and others. In the midst of this mass of earth is placed the cocoon, of a beautiful orange yellow color, but not perfectly globular, having the shape of a little flask.

The particles of earth which enclose this are held together by filaments of silk, but are not enveloped by white silk, as is the case with Tegenaria agrestis. The immediate envelope of the cocoon is a pellicle so compact

[1] McCook: "A Spider that makes a Spherical Mud Daub Cocoon." Proceed. Acad. Nat. Sci., Philadelphia, 1884, page 151.

[2] Walckenaer, Aptères, Volume II., page 8.

that one can tear it. Walckenaer found, August 20th, twenty-six spiderlings perfectly developed enclosed within a cocoon. Each was about a millimetre long, of a milk white color, the eyes not very distinct. In another cocoon, found at the same period, he counted twenty-three eggs. He saw no web near the tube in the neighborhood of the cocoons.[1] Examples of the same mode of treating cocoons by the European Agrœca brunnea have already been given.

While walking through the fields near the home of Mr. F. M. Campbell, at Hoddesdon, Hertz, England, I noticed a number of pretty, spherical nests which had been formed by massing together spikelets of a species of grass. A ball about the size of a hickory nut, that is to say, one inch in diameter, was thus formed. At first sight I took this to be the work of lepidopterous larvæ, but upon plucking some nests the spinningwork which bound the spikelets together appeared to be spider silk rather than that of a moth larva.

FIG. 158. Cocooning nest of an English Drassid, woven upon tops of grass. (From Nature.)

One of the nests was therefore opened and proved to contain a species of Drassid which I took to be a Clubiona. Unfortunately, the specimens which I had preserved for further examination were lost, and I can only give this general identification. The species, as I remembered it, seemed much like our American Clubiona pallens, or the English Clubiona holloserícea. The drawings (Fig. 158) were made from specimens which I brought home, and upon careful examination prove beyond doubt to be the home nest of a spider, woven upon heads of a grass somewhat resembling maize, probably Leersia oryzoides Swz., or Rice Cut-grass. When cut open, a hollow sphere of white silk is disclosed, which is the dainty cell in which the aranead lived. A veritable fairy palace! Among the British Clubionidæ, as described by Blackwall and Staveley, I can only find one species, Clubiona erratica, whose habits would suggest such a nest as this. The cocoon of this species is white and nearly round. The mother places it in a nest, around which she forms a guard by binding together the branches of firs or other plants in the midst of which she is placed. She remains in the nest with her young.[2]

[1] Aptères, Volume II., page 14. [2] Staveley, British Spiders, page 110.

This species, however, as described by the English authors, does not correspond with my recollection of the inhabitant of the pretty nest which I have noticed. It is possible that my memory may be at fault, and that this cocooning tent was prepared by the female of Clubiona erratica. American Drassids, as we have seen, make similar spherical nests, but I know none that thus hangs them to foliage.

Cocoon Nest.

The substantial agreement in cocooning habit between the Drassids of America and those of Europe may further be seen by comparing the following descriptions of English species. The female of Drassus ater constructs a large white cell of close texture, usually in a hole in the earth or under a stone. Within this, in the month of May, she places a plano convex cocoon, which is attached by its flat side to the stone or other substance on which the cell is formed. This cocoon is white or slightly yellowish at first, but afterwards becomes yellowish in color. The female remains on guard by her eggs.

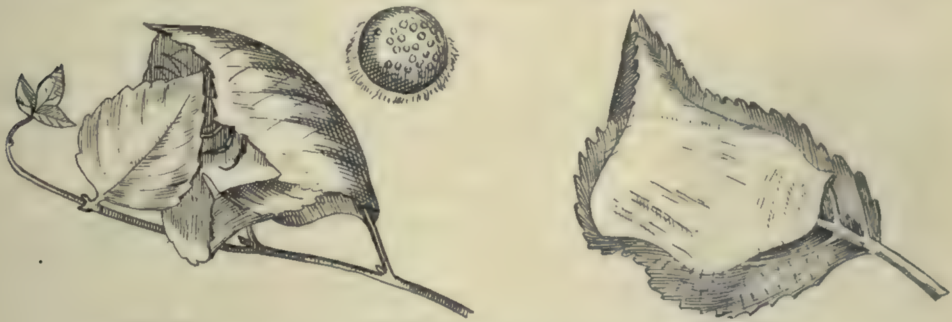


FIG. 159. FIG. 160. FIG. 161.

De Geer's sketches of Clubiona cocoon nests.

FIG. 159. On birch leaves. FIG. 160. Cocoon of the same. FIG. 161. Nest on an apple leaf.

English Drassids.

The cocoon of Drassus sylvestris is white, of a flattened shape, and a little less than one-third inch in diameter. It is formed in July and concealed in the silken cell in a hole in the earth under stones. The mother is usually found with her cocoons.

Drassus lapidicolens conceals herself in a cell formed between the surface of the earth and the under side of a stone, near which she spins some threads, forming an irregular square. In this cell, in the months of July and August, she places her cocoon, covering it with dead leaves. This, at first, is in the form of a flattened sphere, but becomes nearly round when the young are about to escape. It is white and about one-half an inch in diameter. The mother remains with her young some time after the eggs are hatched. The cocoons formed by the beautiful little Drassus nitens are about one-sixth inch in diameter, hemispherical, and white. The mother inhabits a tube which proceeds from the upper side of the cocoon.[1]

[1] See descriptions of Blackwall and Staveley.

I present in this connection two of the earliest published figures representing the spinningwork of spiders of this family, both of them probably belonging to the genus Clubiona. They were made by that pioneer araneologist, Baron De Geer. Fig. 159[1] represents a leaf nest with the spider within it, woven on the inner surfaces of birch leaves. This constituted the mother's dwelling and the egg nest of her cocoon. The mother remained with most of her body concealed within her nest, but her fore feet were held outside ready to seize whatever prey might pass by. Fig. 160 is the cocoon separated from the enclosing nest. Fig. 161 represents an apple leaf within the concave inside of which is seen a white cell spun by the female of Araneus pallidus Clerck ("Araignee tapissiere"), apparently a species of Clubiona. It serves as a dwelling for the mother and contains also her cocoon, within which the eggs are deposited and the young hatched. The nest was sketched July 25th. It was opened and the spiderlings found within with their mother. The mother showed no fear, but stayed by her little ones closely, even during the process of tearing open the nest for examination.[2]

De Geer's Figures.

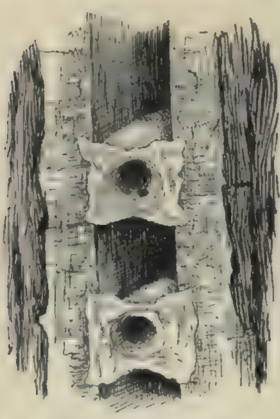


Fig. 162. Snare and nesting tube of Dysdera bicolor.

The Dysderads form one of the most interesting families of the Tubeweavers, and are especially distinguished by having six instead of eight eyes, six spinnerets, and four breathing holes. In their general habits they are closely related to the Drassids, living in tubes or cells of silk formed under stones in cracks and crannies of walls, fence rails, old trees, and similar places. Our most common species in this geographical province is Dysdera bicolor.[3] I have found it in great numbers occupying numerous interstices between the stones of an old barn in Delaware County, and in the interspaces between door jambs and window frames of the wall.

Dysdera bicolor.

Tubes of all sizes, from those of baby spiderlings to grizzled adults', had their outlet upon the wall surface, at which points the tube widened out into a rectangular margin or flap, by which it was attached to the wall. The species is widely distributed over the adjoining fields, in fences, etc., and the accompanying figure was drawn from a huge walnut tree that stood solitary in a meadow. The trunk was cleft by a longitudinal fissure twelve feet or more in length and from an inch to two inches wide. The bark was stripped off along the edges of this fissure, and within the crevice ten or twelve tubes were spun, extending

[1] Mem. des Insect., Tom. VII., plate xviii., Figs. 8-9. [2] Idem, page 268, pl. 15, Fig. 16.
[3] Ariadne bicolor Emerton, New England Drassidæ, page 38.

inward for two inches and more. The silk of the tube was fine, but the flap of netted work by which it was attached to either side was of coarser fibre. (See Fig. 162.) The tubes were spun all the way up the fissure to the fork of the trunk.

Fig. 163. Female Segestria canities.

The spiders watch near the orifice of their tubes with the first three pairs of legs directed forward, an unusual position, as spiders usually have only the first two pairs thrust outward.

The cocoon, containing twenty or thirty eggs, is placed within the inner part of the tube in July and August. Emerton[1] saw one in this position July 10th, and another under a stone with a cocoon containing thirty-four eggs. The English Dysdera hombergii spins her egg sac within her tube in June; it is an oval cell, within which are from twenty to thirty pinkish eggs loosely bound together. The cell is slightly woven, and is covered with particles of gravel or other extraneous matter. It thus appears that the cocooning habits of the genus as represented in Europe are the same as those of our American species.

In material sent me from San Bernardino, California, by Mr. Wright, were cocooning nests of a peculiar type made by a species of Segestria, which appears to be new, and which I have named Segestria canities. (Fig. 163.) The species was determined from young spiders found enclosed in some of the cocoons. Subsequently, I received from the same section, through Mrs. Eigenmann, two mature females, which enabled me to confirm my previous determination, and thus to identify the cocoons which are here described. The species is shown at Fig. 163, and a view of the face at Fig. 164.[2]

Segestria canities.

The mother Segestria spins a series of flattened disks, which are overlaid one upon another like tiles upon a roof, and are bound by silken threads somewhat after the fashion of Epeira labyrinthea's cocoons. This series of cocoons is sometimes three inches or more in length. The examples sent me were covered (apparently intentionally) with leaves, from the plant upon which the string had been suspended, resembling the leaves of spruce or hemlock. Along the entire length of one side of the cocoon string the mother had spun a silken tube, within which she dwelt. The manner in which the string is suspended is represented in Fig. 165. It hangs within a maze of intersecting cross lines like the

Fig. 164. View of eyes and face of Segestria canities.

[1] Notes, Hentz's Spiders U. S., page 22.

[2] The spider is about three-eighths inch long; the cephalothorax brown, the abdomen brownish yellow covered thickly with white hairs, which also strongly mark the cephalothorax, suggesting its specific name. The legs are yellow, with brown rings at the joints and a similar ring in the middle of the tibia.

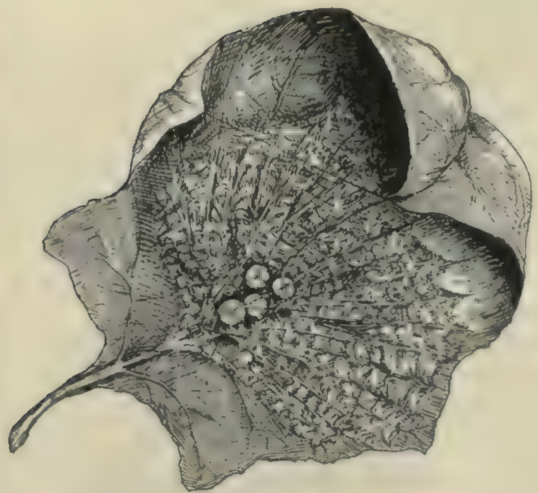


Fig. 168.

Fig. 167.

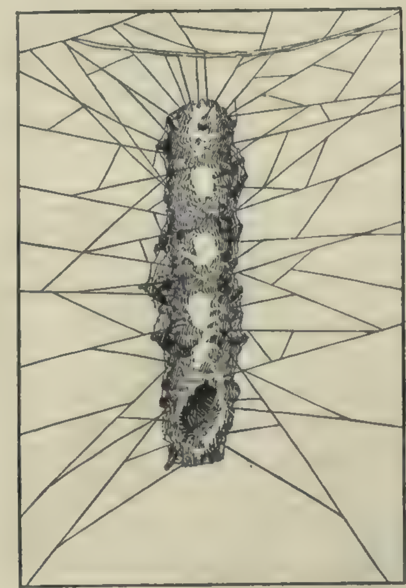


Fig. 165.

Fig. 166.

Fig. 165. Cocoon string of Segestria canities, with domicile tube alongside. Fig. 166. The same, side view, and cocoons covered with leaves. Fig. 167. Cocoons of wall loving Dictyna within a sewed leaf. (Natural size.) Fig. 168. The same, snare and cocoons on inside of leaf.

webs of Lineweavers; is attached above to a strong thread, and is stayed and balanced by various guy lines along the entire length. On opening the several cocoons of one of these strings I found (in one of twelve cocoons) the first seven contained only the first moults or shells of the escaped spiders; the next three, young spiders in successive degrees of advanced growth; and the last two, eggs alone.

The exterior case of the cocoons is a light straw color or creamy white. It is made of two saucer shaped pieces well woven together at the edges, and is about three-eighths of an inch in diameter. Fig. 166 gives a side view of a cocoon string, showing the way in which the cocoons overlap one another.

Dictyna. Dictyna usually makes several cocoons, small flattened globes of pure white, about one-eighth inch diameter, which are placed within the snare, usually grouped near one of circular doors on which the web lines converge. (See Vol. I., page 349.) When she spins her web along a brick wall or like surface, the cocoons are fastened to the wall, arranged along the angle or clustered together loosely. When the spider makes her snare within a leaf, as she frequently does, the cocoons are placed upon the leaf, protected, of course, by the enclosing cross lines. The mother is found near her cocoons, though apparently not exercising any special vigil upon them. She simply lays her eggs in the position most convenient to herself. The edges of the leaf are sometimes drawn well together (Fig. 167) and sewed in the prevailing aranead style; but more frequently the edges of the leaves are simply bent over by silken lashings as in Fig. 168. This cut is drawn from a sketch made on the grounds of the Smithsonian Institution, Washington.

III.

Territelariæ. Of the typical cocoons of the Territelariæ we may speak with some positiveness; but the number of species whose cocoons are known is small. However, it is highly probable that the variety of form and method of suspension and care is not great, and we may perhaps conclude that we possess a good knowledge of the general cocooning habit of the tribe.

Mr. Enock determined the position in which the mother Atypus piceus spins her cocoon. In a tube ten inches long and from a half to five-eighths inch in diameter he found that about six and a half inches below the surface the tunnel widened into a sort of pouch. On opening this he saw the mother's cocoon suspended in a beautiful hammock of silk one inch long, the flat ends of which were about three-sixteenths of an inch wide, and were attached to the top and bottom of the pouch.[1]

This description entirely corresponds with that previously recorded by

[1] Life History of Atypus piceus, Trans. Ent. Soc. Lond., 1885, page 394.

M. Eugene Simon[1] and by Mr. Pickard-Cambridge.[2] Mr. Simon has made a drawing of the cocoon as found by him in natural site, which I reproduce from the paper just quoted. The earth is therein shown dug away to disclose the burrow, and the projecting tube is seen as laid along the surface. (See Fig. 169.) Instead of the hammock which Enock describes, Mr. Simon says that a number of threads are used to suspend the cocoon in the throat of the enlargement of the burrow.

Atypus' Cocoon.

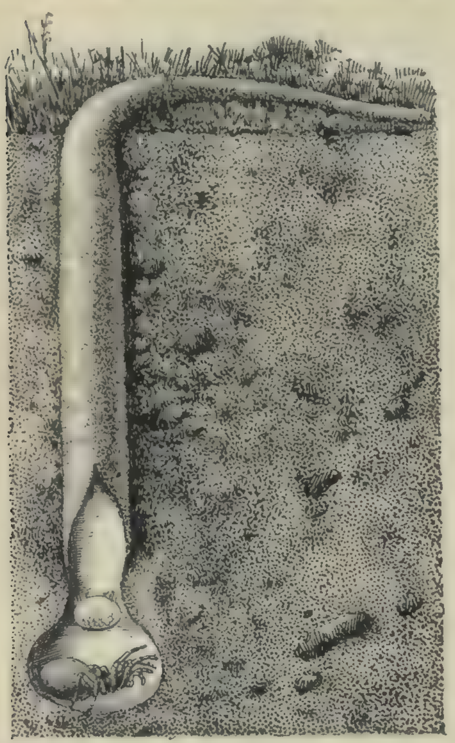


Fig. 169. The cocoon of Atypus piceus, suspended within her tunnel. (After Simon.)

Mr. Enock found the male of Atypus piceus in the tubular nest of the female October 15th, and again October 20th, but the fertilization must have occurred earlier, for the same writer, on August 1st and again on September 1st, found the cocoons containing eggs, and during the months of September and October the young were already found hatched. According to this observer, the number of eggs in the cocoon of Atypus piceus was usually over a hundred. On several occasions he counted the number of young living with a single female, the sum always exceeding one hundred, and sometimes as high as one hundred and fifty-seven.[3] Blackwall, however, states that the mother Atypus deposits between thirty and forty eggs,[4] but in view of the particular and definite statements of Mr. Enock we must conclude that this is a mistake.

Abbot's Atypus of Florida no doubt protects her egg sac in the same manner as Atypus piceus, since, according to Abbot's note, as recorded by Baron Walckenaer,[5] and which I have read in the original manuscript, the young are found, like the offspring of Lycosids, domiciled on the back of the mother after they are hatched.[6]

Abbot's Atypus.

[1] Annals of the Entomological Society of France, fifth series, Tom. III., 1874, page 114 and pl. 4.

[2] Spiders of Dorset, page xxxiii., Introduction.

[3] Op. cit., page 392.

[4] Spiders of Great Britain and Ireland, page 15.

[5] Hist. Nat. des Insectes, Aptères, Vol. I., page 248.

[6] McCook, "Nesting Habits of the American Purseweb Spider," Proceed. Acad. Nat. Sci., Phila., 1888, page 213.

That accomplished French arachnologist, M. Eugene Simon, has recently added largely to our knowledge of this interesting tribe. A visit to South America enabled him to make personal studies of trapdoor nests, and these have happily found expression in admirably drawn plates, some of whose figures I have ventured to redraw for these pages. Rhytidicolus structor is a common species in Venezuela, particularly upon the slopes of compact and sandy ground. Its burrow is the most complex that Simon observed. It is composed of three successive spacious chambers, communicating one with another by straight openings, which close by a hinged door.

Simon on Trapdoor Spiders.

The first chamber is largely dilated in the form of a pear, but quite contracted at the two extremities. (See Fig. 170.) The second chamber is more or less cylindrical, and terminates in a cul de sac. The third chamber communicates with the second, not by its extremity, but upon the side, which is dilated and oval, like the first, and rounded at the bottom. The walls of the entire burrow are perfectly built, very smooth, and draped with a white tissue, light, transparent, and adhering. The three doors are almost alike. They are thick, cut like a stopple upon the edge, and penetrate within the opening, which is itself slightly widened and a little prolonged beyond the surface. They are semicircular, and cut in a straight line on the side of the hinge. Their superior faces are rough, like the adjoining soil, even with the inside doors; sometimes at an external opening the doors are a little swollen, and very unequal, but always slightly concave on the internal doors. The internal faces of the doors are convex, and have a silk drapery like that of the walls. On the edge of the bevel are small holes for the attachment of the claws when the trap is to be held down, and these are more distinct on the entrance door. This swings naturally from within to the outside. The second door opens, on the contrary, from the outside inwardly in such manner that in the first chamber the two doors show the internal faces equally smooth. The arrangement of these doors is shown in the figure.

FIG. 171.

FIG. 170. Section in the earth, showing trapdoor nest of the female Rhytidicolus structor. (After Simon.) FIG. 171. Outline of first chamber of Rhytidicolus structor, to show location of cocoon.

The female deposits her eggs in the first chamber; they are not agglutinated, and are enveloped in a cocoon of white, opaque tissue, much longer

than large, and are suspended obliquely, like a hammock, between the opposite walls, as shown in the outline sketch, Fig. 171.

Burrow and Cocoon of Psalistops.

Among the Venezuelan Aviculariдæ Simon discovered and describes an interesting species, which he names Psalistops melanophygia. It is a common species in the neighborhood of Caracas, particularly in the forest of Catuche. It digs a burrow in the ground six or seven inches in depth, garnished toward the top with a silken lining slightly adherent. The burrow is quite straight in the upper part, from which proceeds a simple branch, straight and quite long, cutting the main entrance at an acute angle, and mounting near to the surface of the earth. (See Fig. 172.) Below the point at which this side branch enters, the main burrow is much enlarged and more or less curved towards the bottom. From this point also it is destitute of a silken lining.

Fig. 172. The burrow of Psalistops melanophygia, showing the cocoon suspended at the bottom. (After Simon.)

The opening to the burrow is without a trapdoor. It is slightly elevated above the surface, where it is always garnished by a collarette of dry leaves or any other sort of débris retained within the threads. The eggs, which were observed on the 12th of January, are not agglutinated. They are enveloped in a simple cocoon of cottony tissue, white and opaque; are placed near the bottom of the burrow, and suspended from one of the walls by a very short pedicle or stalk.[1] (See Fig. 172.)

Tarantula Cocoon.

A large female Tarantula, probably Eurypelma hentzii, or a closely related species, was sent to me from the West Indies, and arrived at the Academy during a prolonged absence. She died before my return, and was preserved in spirits; but afforded me an opportunity, which I had long desired, of determining the egg cocoon made by this family of the Theraphosoidæ. While cleaning out the box in which she had been sent I observed a piece of spinningwork within, which proved to be an abandoned cocoon. When inflated it showed a hollow spheroid composed of thick silken cloth, somewhat soiled on the outside, but within clean and white. It measured two inches along the longer axis and one and one-fourth inch along the shorter one. It

[1] Simon, Arachnides de Venezuela, page 197, plate 3, Fig. 1.

was empty of young, whose first moults, however, were within the cocoon, as were also a few unhatched eggs, which are yellowish spheres three millimeters in diameter. Three small openings in the case showed where the spiderlings had escaped. Both cocoon and eggs are shown natural size in the accompanying figure. (Fig. 173.)

The interior of this cocoon was without any flossy lining or padding, resembling thus the egg sac of the Lycosidæ generally. A curious flap overlapped the cocoon at one side, whose use I could not conjecture, unless it may have served to attach the object to the mother's body, or suspend it within her burrow; or perhaps it was simply a remnant of material which had remained after the eggs were rolled up within the silken rug upon which they are probably deposited after the manner which I have shown to exist in the genus Lycosa.[1]

Fig. 173. Cocoon and eggs of the Tarantula (Mygale). Natural size.

Mode of Carrying.

The janitor who received the box containing this spider and placed it in my room was at the time new in his position, and did not understand the importance of observing all the particulars in the habits of living creatures sent to the Academy. He therefore failed to make any notes, but told me, when questioned, that he believed the cocoon was attached to the lower part of the spider's body when it arrived. No doubt this is a correct observation, and we may assume with some degree of certainty that the large egg sac of the Theraposids is carried by the mother, lashed to the spinnerets at the apex of the abdomen, precisely as in the case of Lycosids, whose well known habit is familiar to every frequenter of our fields.

This cocoon is exhibited in my collection of aranead architecture deposited in the Philadelphia Academy, and is the only one, as far as I have been able to learn, exhibited in any similar institution. A second specimen in my possession is similar to this, except that the silken sac is

[1] See Proceedings Academy Natural Sciences of Philadelphia, 1884, page 138, my note on "How Lycosa fabricates her round Cocoon."

of much more delicate tissue, it probably having been made in confinement. Termeyer speaks of cocoons of the Mygalidæ of South America ("Aranea avicularia") even greater than the above. They are three inches long by one wide, and are placed in the fissures on trunks of trees. They contain thousands of eggs. This extraordinary size of the cocoon had made the inhabitants, who do not observe carefully, imagine that this spider would take the cocoon of "the bombice moth, del Guyavo (Janus, Linn.)," and, having destroyed or eaten the chrysalis, would place her own eggs therein, and then artificially close the hole by which she had penetrated it. One of these cocoons weighs as much as six cocoons of the silk worm before they are washed, and as much as three or four after having been washed.[1]

Size.

In San Domingo, according to Palissot de Beauvois, Mygale blondii is found in the fields, where it prepares a hole in which it awaits its prey. It does not confine itself to this manner of providing its food, but issues forth evening and morning, climbs up trees, and, penetrating into the nests of small birds, sucks their eggs or the blood of their little ones. The female's cocoon is the size of a pigeon egg.[2]

Walckenaer describes the cocoon of Mygale avicularia as composed of three silken envelopes, of which the middle one is thinner, and does not contain a silken padding. The female places her cocoon near her tubular dwelling, and watches it assiduously.

Mygale avicularia.

M. Moreau de Joannès, as quoted by Baron Walckenaer, says that the female of this species in Cayenne envelopes, in a cocoon of white silk, her eggs, to the number of eighteen hundred or two thousand. He observes that the red ants eat the little Mygalidæ when they issue from the cocoon. M. Guérin had in his collection a cocoon of this Mygale which was covered over with a multitude of very small parasitic Cynips. This cocoon was flattened, rounded, and about three inches in diameter. It was opened in the presence of Walckenaer, and the young spiders were found enclosed therein.[3]

Madame Merian, who first recorded a report that the Theraphosoidæ prey upon small birds, must have observed the cocoon of these spiders, as it seems to me. She indeed speaks of them as having their domicile in a large round nest resembling the cocoon of a caterpillar; but the plate to which she refers is a fairly accurate figure of a female tarantula with a large oval cocoon attached to her abdomen, in the way usual to Lycosids.[4] I have the opinion that the egg cocoon of the spider was mistaken by Mademoiselle Merian or her informants for a "domicile."

[1] Communications Essex Institute, Vol. V., 1866–67, page 61. "Researches and Experiments upon Silk from Spiders and upon their Reproductions, by Raymond Maria de Termeyer." Translated from the Italian, and revised by Burt G. Wilder.

[2] Walckenaer, Aptères, Vol. II., page 211. [3] Aptères, I., 218.

[4] Desertation sur la Generation et les Transformations des Insects de Surinam. Mariæ Sibillæ Merian. À la Haye, MDCCXXVI. Fig. 18 and explication.

At all events we may consider it fairly well assured that, in her cocooning habits, the female Tarantula throughout most, or perhaps all, species, closely resembles the Lycosidæ, and the resemblance probably extends to all the Territelariæ. In other words, the Theraphosid cocoon is, first, round or ovoid; second, is carried about with the mother, attached to her body, or kept under her care; and, third, the young for a period longer or shorter remain with their mother. The affinity between these two great groups of araneads is also marked in their nesting habits; both burrow into the ground a cylindrical tunnel or shaft, within which they domicile, sometimes lining it more or less completely with silk.

Summary

IV.

Passing now into the group of Wandering spiders, we reach the cocoonery of the Citigrades, and here find little variety in structure, with scarcely an exception. The cocoons of this tribe are round balls without any interior furnishing, which are carried by the mother within her jaws, as in the case of Dolomedes, or lashed to the spinnerets, as with the Lycosids and most other species. (Fig. 174.) The manner in which the cocoon is made has been quite fully described by myself.[1]

FIG. 174. Lycosa carrying her round cocoon lashed to her spinnerets.

Lycosa's Mode of Cocooning.

While walking in the suburbs of Philadelphia, I found under a stone a female Lycosa (probably L. riparia Hentz), which I placed in a jar on dry earth. For two days the spider remained on the surface nearly inactive. The earth was then moistened, whereupon (May 2d) she immediately began digging, continuing until she had made a cavity about one inch in depth and height. The top was then carefully overlaid with a tolerably closely woven sheet of white spinningwork, so that the spider was entirely shut in. This cover she fortunately made against the glass side of the jar, and the movements of the inmate were thus exposed to view. Shortly after the cave was covered the spider was seen working upon a circular cushion of white silk, about three-fourths of an inch in diameter, which was spun upwards in a nearly perpendicular position against the earthen wall of the cave. The cushion looked so much like the work of Agalena nævia, and the whole operations of the Lycosa were so like those of that spider when cocooning, that I was momentarily possessed with the thought that I had mistaken the identity altogether, and again examined her carefully, only to be sure that she was indeed a Lycosid.

[1] "How Lycosa fabricates her round cocoon." Proceed. Acad. Nat. Sci., Phila., 1884, page 138.

After an absence of a half hour I returned to find that in the interval the spider had oviposited upon the central part of the cushion, and was then engaged in covering the hemispherical egg mass with a silken envelope, working like a mason spreading mortar with a trowel.

Forming the Ball.

Unluckily, at this stage of work I had to leave for an imperative engagement, and did not see my spider again for an hour and a half, when I was delighted to find a round silken ball dangling from the apex of her abdomen, held fast by short threads to the spinnerets. The cushion, however, had disappeared. It is not difficult to explain the intervening process. Within this circular cushion the eggs are deposited, after which act the spider proceeds to pull the edges of the cushion together until the whole is rolled around the egg mass, after the fashion of a schoolboy putting a leathern covering on a yarn ball. This done, the mother goes over the exterior of the ball, and spreads upon it an outer layer of spinningwork, which is woven in the same manner as the

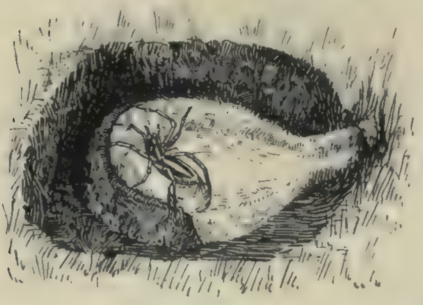


Fig. 175.

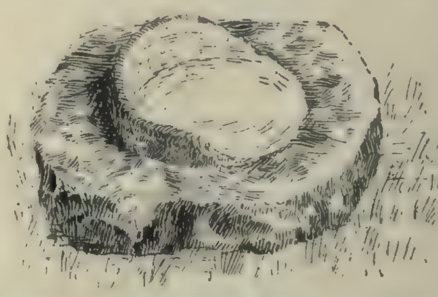


Fig. 176.

Fig. 175. The cocooning burrow of Lycosa saccata, made underneath a stone. The walls of mingled silk and soil. This figure shows the nest as exposed when the stone was removed. Fig. 176. The stone under which the burrow of Fig. 175 was made. The under part of the stone is shown turned upward.

original cushion. Thereupon she attaches it to her spinnerets, where it is carried until the young are hatched. I had often wondered how the round egg ball of the Lycosid was put together, and the mechanical ingenuity and simplicity of the method were now apparent. The period consumed in the whole act of cocooning was less than four hours, and the act of ovipositing took less than half an hour. Shortly after the egg sac was finished the mother cut her way out of the silken cover woven over her little cavern. She had evidently thus secluded herself for the purpose of spinning her cocoon. This was in accord with a firmly fixed habit of the Lycosids to exclude themselves, before making their cocoons, in a burrow or cave which they form in the ground. This is often made under a stone and is protected on the sides by a plastered wall of mud, and above against the stone by a piece of spinningwork which thus forms an upholstered roof to this pretty, cavernous home. An approach to the cave is cut, which often debouches among the grasses, clumps of clover, mosses, or wild flow-

FIG. 177. Leaf woven cocoon nest of Dolomedes sexpunctatus.

ers, that give a touch of natural beauty to the gateway. One of these Lycosid cocooning caves is shown at Figs. 175 and 176. It was made beneath a stone, and when that was lifted up the spider, Lycosa saccata, showed within as at Fig. 175. The roof of her den was broken off by lifting and is shown in inverted position at Fig. 176. The use of this special cocooning den is common with Lycosids; but some species, and probably all at times, live within the home burrow while carrying their cocoons. This is the habit of Lycosa arenicola, which may often be seen on her turret with her egg ball at her spinnerets. (See Vol. I., page 314, Fig. 289.)

There is no flossy wadding within the cocoon case of Lycosids, as is common with Orbweaving spiders. Indeed, such a provision for the comfort and safety of the brood appears wholly unnecessary in the case of younglings whose egg life is so brief, and of a mother who carries her young about with her, and thus gives them the advantage of her personal protection and care. The Orbweaving mother generally dies within a few days after ovipositing. Personal protection of her offspring is therefore impossible, and the period of development is often greatly prolonged. Nature has taught her to provide for them the necessary covering of a warm, flossy, silken blanket beneath which they may outlive the changes of weather.

In the case of Dolomedes, the cocoon is carried by the mother until shortly before the period of hatching, when it is generally deposited within a pretty nest composed of leaves drawn together and lashed at the edges into the form of a tent. (See Fig. 177; also Vol. I., Fig. 339.) Within this a mass of intersecting lines is spun, upon which the cocoon is hung. After hatching the spiderlings occupy the temporary home thus provided for them, and hang in clusters or individuals upon the intersecting lines.

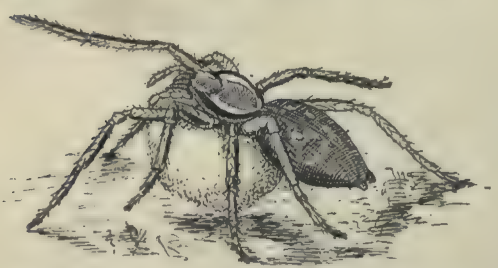


FIG. 178. Dolomedes sexpunctatus carrying her cocoon.

Dolomedes differs from Lycosa in the mode of deporting her cocoon, suspending it beneath the abdomen and sternum, so that it is surrounded by the legs. (Fig. 178.) When walking, the mother Dolomede must straighten out her legs as much as possible, and carry her body high. (Figs. 178, 179.) The cocooning habits of the English Dolomedes mirabilis differ in no particular from those of our American species. She carries her cocoon, which is large, globular, and of a dull yellowish color, attached to her body during all her hunting expeditions, until the time approaches for the hatching of the eggs. She then weaves a sheet of close, fine silk upon grasses or the branches of bushes, forming a dome, of which these supply the rafters.

Among the Citigrades, Pucetia aurora has a special interest, both from its appearance and structure and from the peculiarity of its cocooning habit.

Pucetia aurora.

This spider was received in collections sent me by Mr. W. G. Wright, of San Bernardino, California. Numerous specimens of young and old were subsequently sent by Mrs. Eigenmann and others from the same locality. The genus Pucetia belongs to the family Oxyopoidæ of the Citigrade spiders, to which it is doubtless relegated in spite of certain analogies with the Satigrades on the one hand and the Laterigrades (Philodrominæ) on the other.[1] Mr. Wright describes the specimens sent me as jumping spiders; and Hentz, who describes several species under the generic name of Oxyopes, says that Oxyopes salticus leaps with more force than Attus. This family is arboreal in habit; the spiders are found on plants, with their legs extended, thus practicing Tetragnatha's form of mimicry, and thence springing upon their prey. The female's cocoon is usually conical, surrounded with points, placed in a tent made between leaves drawn together and lashed, and is sometimes of a pale greenish color. Oxyopes viridens will make a cocoon suspended midway by threads attached to these external prominences, and this she will watch constantly from a neighboring site. Hentz also thought that the mother of this species carries its young like a Lycosa.[2]

FIG. 179. English Dolomedes mirabilis carrying her cocoon. (After Blackwall.)

Pucetia aurora appears to be a new species.[3] The body length is fourteen millimetres; the legs are long and tapering, except among the young. The body is yellow and pale yellow; the cephalothorax striped longitudinally with bright red streaks; the abdomen marked above with red streaks; the sternum is red; the legs are yellow, with red rings at the joints. These red streaks upon the yellow background suggested the specific name of "aurora."

The cocoon nests, according to Mr. Wright, are uniformly placed upon bushes of Erigonum corymbosum. They are hung from three to four feet above the ground, and, being upon the topmost twigs of the plant, are easily seen from a distance. The cocoons, received by me in considerable number, are straw colored spheres five-eighths of an inch in diameter. They are covered externally with various pointed rugosities, from which numerous lines extend to the adjoining corymb of the plant upon which

[1] Thorell, On European Spiders, page 196. [2] Spiders of the United States, page 48.
[3] Proceed. Acad. Nat. Sci., 1883, page 276, "Notes on two new California Spiders."

all the specimens sent are attached. (Fig. 180.) The retitelarian snare which surrounds the whole doubtless serves as a temporary home for the young spiders. The cocoon has no suture, and the spiderlings escape by cutting the case, which is thick and closely woven. No flossy padding was found inside of the case. (Fig. 181.) The cocoon thus resembles that made by Citigrades generally.

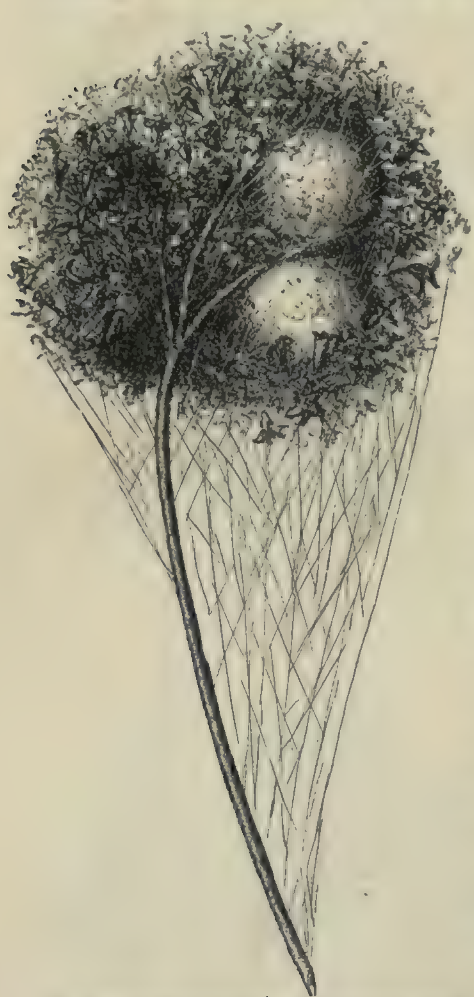


Fig. 180. Duplex cocoons of Pucetia aurora, woven among the blossoms of Erigonum corymbosum.

A fine, large species of Ctenus from Central America, sent to me by Mr. Samuel H. Scudder, carried its cocoon. This was a large object, one inch and a quarter long, constructed in the ordinary manner of Lycosid cocoons, but differing somewhat in shape, being globular instead of hemispherical. The mother carried it for some time after she came to me, and then fastened it by threads, in hammock fashion, to the side of the box wherein she was confined. Shortly thereafter a large brood of spiderlings appeared, spread themselves over my laboratory table, covering the books and other objects thereon with a sheet of fine spinningwork. They finally built upward a huge bridge like structure, a sort of aranead Eiffel Tower, which touched the ceiling above the table, and at another point diverged to the laboratory window. Some further account of this brood, with a figure of their bridge at a certain stage, will be found in the subsequent chapter on Cocoon Life and Babyhood.

V.

Among Saltigrades the cocoons closely resemble those of many of the genus Epeira. They are spun against some surface, as that of a rock or tree, the eggs being overlaid by a thick blanket of white spinningwork. Over this again is stretched a tent or cell of lighter structure, although still of close and somewhat adhesive texture, but not so thick as to prevent the cocoon from being seen through it. The eggs are heaped in a hemispherical mass, and are of a pinkish or light rose color. In the case of Phidippus morsitans the cocoon is from one-half to three-fourths of an inch in diameter. The spider dwells within her cell, and of course close

by her cocoon. The outer covering of the eggs is quite thick, very white, and apparently a little viscid; at least, it is quite adhesive. The exterior tent has something of the same quality. (Fig. 182.) I sometimes find the cocoon of Saltigrades enclosed within the nesting cell and spun up within a rolled leaf, as shown at Fig. 183, a beautiful example of aranead sewing. Fig. 184 shows the leaf opened up, disclosing the tubular nest, and again the mass of eggs much enlarged and displayed against the egg case thrown back, the egg case, of course, being within the cell.

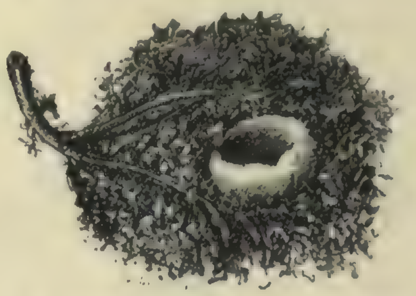


FIG. 181. Cocoon of Pucetia aurora, opened to show structure.

One of the most elaborate cocoon nests woven by a Saltigrade spider is that made by Phidippus opifex of California.[1] The examples both of nests and spiders in my possession were sent me by Mr. W. G. Wright, of San Bernardino, California. The cocoon nest is externally an egg shaped mass of white spinningwork, sometimes three inches long by two and a half inches wide, but often less, as in Fig. 185, which is drawn natural size. The outer part consists of a mass of fine silken lines crossing in all directions and lashed to twigs of sage bush, within which it is enclosed. This maze surrounds a sack or cell of thickly woven sheeted silk, irregularly oval in shape, two inches long by one inch in width, and also attached to the surrounding twigs. At the bottom this cell or tent is pierced by a circular opening which serves the spider as the door of her domicile. Like others of her genus Opifex lives and hibernates within this silken tent. Against an inner side of the tent she spins a lenticular cocoon (of double convex shape), consisting of thick white silk, within which the eggs are placed. When the cocoons sent me reached Philadelphia many young spiders had escaped and occupied the package box. They were about one-eighth inch long, resembling the mother, but less heavily coated with gray. The spider herself is a large example, five-eighths of an inch in body length, stout, the legs of moderate thickness, the whole animal covered closely with grayish white hairs, the skin beneath which is

FIG. 182. Cocoon tent and cocoon of Phidippus morsitans spun upon a rock.

[1] The spider and its habits were originally noticed by me in Proceedings Acad. Nat. Sci., Philadelphia, 1883, page 276.

Fig. 183.

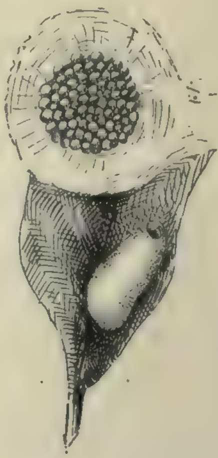


Fig. 184.

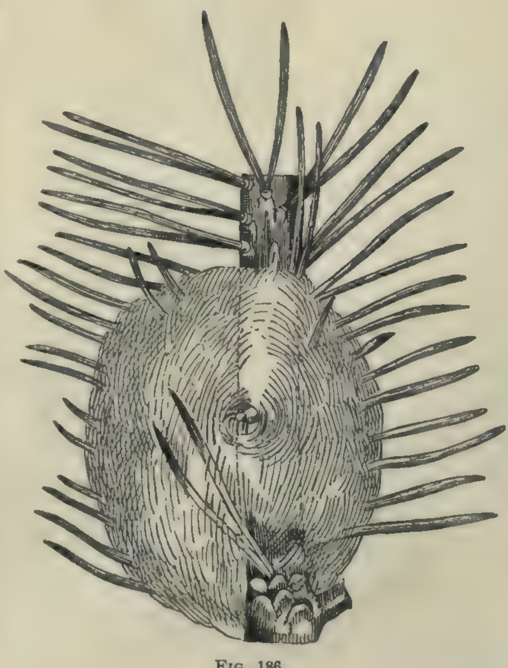


Fig. 186.

Fig. 185.

Typical Saltigrade Cocoons.

Fig. 183. Sewed leaf tent of a Saltigrade spider. Fig. 184. Leaf opened to show the silken cell and the egg mass (enlarged) in the open cocoon. Fig. 185. Cocoon nest of Phidippus opifex. (Natural size.) Fig. 186. Fac simile of a figure of an Attus cocoon nest, by Baron De Geer.

black. I named the species Attus opifex, but according to Professor Peckham it belongs to the genus Phidippus.[1]

I present in this connection a fac simile drawing of perhaps the earliest sketch of a Saltigrade cocooning nest. July 26th, 1745, Baron De Geer found among the needle like leaves of a pine tree a large, oval cocoon nest of white silk, which was woven around the branch and interlaced with the leaves. (Fig. 186.) The spider was inside along with her little ones, who were present in great number. In the middle of the cocoon nest, at the side, was a door, at which the spider stayed on guard; but generally she was within the tent with her little ones, preferring the back or middle part thereof, near the supporting branch. De Geer found at the entrance detritus of flies and other insects which had been devoured by the mother, such as the legs, wings, etc.

The spiderlings accompanied the mother, and appeared to live on good terms with her. They were about a line long, but otherwise quite resembled the mother, having black bodies and brown legs. They moved with great vivacity and appeared to be nourished, in common with their mother, by the prey captured by the mother. The species appears to be Dendryphantes hastatus Clerck.[2]

VI.

Among Laterigrades a very general habit is to spin a plano convex cocoon of tough silk fibre, which is attached to some surface. Sometimes a light shelter tent is spun over this, and the spider will be found dwelling within. (See Vol. I., page 347, Fig. 338.) Thomisus cristatus Clerck, of Europe (Xysticus audax Koch), secludes herself in the leaves and stretches some isolated threads around her, and there sometimes she suspends herself. In this retreat the female lays her eggs in a flat cocoon, one-fourth inch in diameter, the tissue of which is swollen by the eggs, and presents rounded eminences. The spider places herself upon the cocoon and does not abandon it when touched. The cocoon contains one hundred eggs of yellowish white color.[3]

FIG. 187. Cocooning tents of Philodromus mollitor.

The eggs of Philodromus are usually enclosed within a cell which is hung among the leaves or stretched between twigs. (Fig. 187.) The egg sac is surrounded by a slight silken tent, wherein the mother dwells. An example of Philodromus mollitor, in my collection,[4] is woven in the angles

[1] "North American Spiders of the Family Attidæ, Phidippus opifex McCook." Trans. Wisconsin Acad. Sci., Vol. II., 1888, page 20.

[2] De Geer, pages 286, 287. [3] Walckenaer, Aptères, Vol. I., page 523.

[4] This example was sent me by Dr. Geo. Marx as the cocoon of this species.

of forked twigs and are composed of very white stiff silk, the stiffness probably being caused by the tightness with which the lines were spun. (Fig. 187.)

Misumena vatia is well known among the Laterigrade spiders by its remarkable mimicry of the colors of flowers upon which it lurks for prey. A fine example of its cocoon was brought to my notice by a lady who had transported a specimen from the Wyoming Valley to her home in Philadelphia. Her attention had been arrested by the remarkable resemblance of the creature to the bright golden yellow Coreopsis flower on which she discovered it. The spider was placed in her bedroom chamber about the 28th of August, and during the first week in September it wove the cocoon represented at Fig. 188, in a corner of the dressing bureau, just where a mirror is fixed in the woodwork. The cocoon consists of a flossy mass, something after the fashion of that of Epeira, which covers over the eggs. A tent of close white spinningwork encloses this, having at the bottom a circular opening one-eighth inch in diameter, through which the spider passed to and fro. A thicker band of silk, of the most beautiful whiteness, looking like spun glass, passes across the centre of the enclosing tent, joined at one end to the mirror, and at the other to the cabinet work. The tent and cocoon are partly woven upon the glass of the mirror. The tent is about two inches long and one and a half inch wide, and the cocoon, which is somewhat irregular in shape, is about three-fourths of an inch in diameter. A few separate lines are stretched across the entire spinningwork, and attached on either side of the angle or corner which contains the cocoon. A few days after finishing this work of maternal industry the mother died. According to Hentz[1] this species attaches its cocoon to the under side of a leaf, and remains near it.

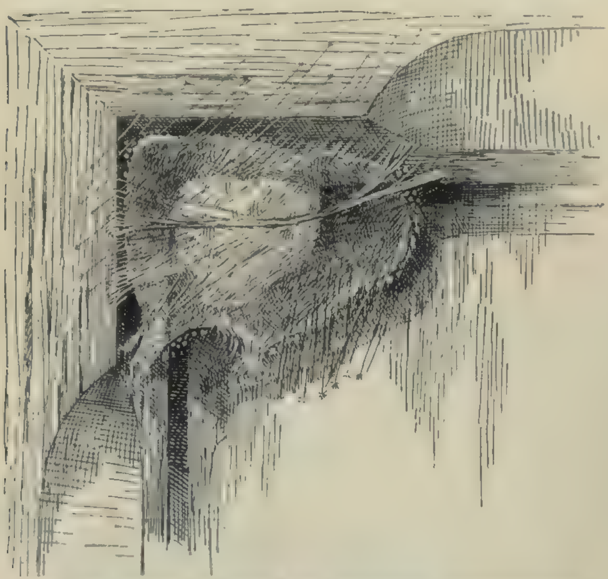


FIG. 188. Cocoon and tent of the Laterigrade, Misumena vatia, woven upon a ladies' dressing bureau.

There is evidently a good deal of variety among the cocoons of Laterigrades. Many of them consist of two stiff, paper like pieces, viz., first, a

[1] Spiders U. S., page 78, on Thomisus fartus.

flat circular plate which is attached to the object, rock, bark, or wood on which the cocoon is spun; and, second, a convex covering which fastens above the eggs like a cap. The inside is lined with pure white silk, but the outside is often of a grayish brown, and apparently is purposely soiled in order to subdue the color. Usually there is no flossy padding for the eggs. I am not sufficiently acquainted with cocoons of this tribe to enter largely into a comparison with those of others, but the forms known to me and above described are probably typical, and substantially represent the maternal industry of the Laterigrades of the United States, and probably of the globe.

FIG. 189. Cocoon of Huntsman spider, as clasped and carried by the mother. (View from above.)

The Huntsman Heterapoda.

The well known tropical species, Heterapoda venatoria, or the Huntsman spider, is one of the largest of the Laterigrade species, and may properly be classed with the spider fauna of the United States, as I have specimens from Florida. It abounds in the West Indies. The cocoon is a large double convex or plano convex object, resembling those of Thomisus and other species when woven against various surfaces. It appears, however, to be carried by the mother; at least, one female preserved by me in a box wove a cocoon of this sort which she carried in the manner represented at Fig 189, which gives a view from above, and Fig. 190 a view from beneath. The button like cocoon was put beneath the body, which it almost entirely covered; at one end it appeared to be attached to the spinnerets, and at the other was held tightly by the outspread palps. The mother made an awkward appearance as she straddled about the box, holding her legs high up and outspread over her cumbersome cocoon.

FIG. 190. Cocoon of Huntsman spider, clasped by the mother. (View from beneath.)

If this be fairly representative of the prevailing habit of this widely distributed species, we have among the Laterigrades also an example of

spiders that protect their cocoons by deportation, in this respect allying the Laterigrades to the Citigrades, Territelariæ, and the few known species of Retitelariæ, by whom cocoons are deported.

VII.

Cave Spiders.

The cocooning habit continues, apparently without any marked change from the normal methods, under the most decided changes of environment and even of life economy and constitution. This is shown by some studies made of the cave fauna of the United States. Prof. A. S. Packard, Jr.,[1] accompanied by Profs. Shaler and F. G. Sanborn, collected a number of spiders from Mammoth, Wyandotte, Bradford, Carter, and Weyer's Caves, obtaining about one hundred specimens in nine species. Six of these, all belonging to the Theridioids, were found in considerable numbers in the larger caves, where there is little or no light, and the climate is little affected by outside changes. These, judging from the printed descriptions, follow closely the characteristic cocoonery of like species in the open air.

Anthrobia mammouthia.

The well known cave species Anthrobia mammouthia was collected, together with cocoons, in the Mammoth Cave under a stone in dry, but not the driest, places. On the bottom and at different points in the cave sometimes two or three cocoons would be found under a stone as large as a man's head. The cocoons were orbicular, flattened, one-eighth inch in diameter, formed of fine silk, and contained from two to five eggs. They occurred with eggs in which the blastodemic cells were just formed, April 25th. The eggs were few in number, and seemed large for so small a spider, being twenty-five thousandths of an inch in diameter. Packard was unable to trace the development of the young and ascertain if the embryos are provided with rudimentary eyes. Two young Anthrobias were hatched out March 3d in his room.

Nesticus pallidus.

Nesticus pallidus[2] was found in Fountain Cave, Virginia, among stalactites where there was no daylight. It spins a weak, irregular web, consisting of a few threads, according to Packard.[3] Among these threads several loose cocoons were found, one containing thirty or forty young just hatched.

Several years ago I received from Prof. Joseph Leidy two spiders collected by him in Luray Cavern, which appear to be Linyphia weyeri. The specimens were not accompanied by any notes as to snares or location, but I have recently received some information concerning Luray spiders

[1] "The Invertebrate Fauna of Kentucky and Adjoining States." American Naturalist, Vol. IX., page 274.

[2] Emerton, "Notes on Spiders from Caves, etc.," Amer. Natr., Vol. IX., page 279.

[3] Id., page 277.

from Mr. Clarence P. Franklin, of Philadelphia, who made an exploration of that cavern in order to collect the fauna living therein. Among the specimens collected and submitted to me are two which appear also to be Linyphia weyeri, and are probably identical with the Linyphia found by Professor Packard in the caves of Kentucky, Indiana, and Virginia, and which have been described by Mr. Emerton.

Luray Cave Spiders.

These spiders were found in a chamber separate entirely from that part of the cavern which is now illuminated by electric lights, and which is entered by a narrow opening. The location is about half a mile from the main entrance of the cave, and is in total darkness. The araneads were found upon the banks of a pool, and were seen crawling about in the light of the torches in the guide's hand. No webs were seen in this spot, though doubtless such must exist.

Their Abode.

In another inner chamber, about one-fourth of a mile distant from the entrance, Mr. Franklin found numbers of webs and at least one cocoon. This spot is also in total darkness, is beyond the influence of the electric lights, and in a comparatively dry part of the cavern, among older formations of stalactite and stalagmite. Upon one stalagmite about ten feet high and two feet to two and a half wide at the base, he found at least fifty webs hanging in various parts of the structure. This stalagmite was roughly fluted from the base to the apex, the fluting being from one and a half to three inches in width. Within the interspaces thus formed were stretched these webs, which appeared to be all of one character, as represented at Fig. 191. This figure was not drawn upon the spot, but is a memory sketch made from notes and recollection of the observation. The web appears to be composed of simple lines stretched across the space and placed between the walls of the fluting, and one above another, so thickly that they touch and form an open hammock or sheet. This when seen was depressed in the centre, and formed a shallow pocket or pouch. In the midst of the intersecting threads, and at one side of the snare, was hung a small cocoon. It is about one-eighth inch in diameter, is composed of fine flossy silk, and contained a small number of eggs.

Cave Webs and Cocoons.

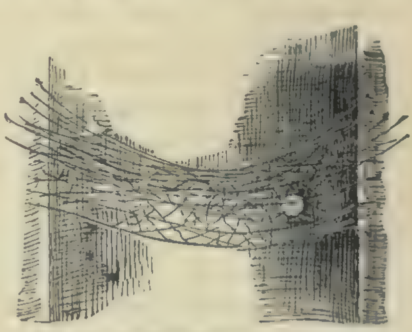


FIG. 191. Snare and cocoon of Linyphia weyeri (?) in Luray Cavern.

I conjecture that the original web consisted of retitelarian lines strung across the flutings, and that these, by reason of use and age, had relaxed and merged one with another, forming the rude sheet like snare described by Mr. Franklin. This characteristic may often be seen in Theridioid snares. Indeed, as I have heretofore shown (see Figs. 211 and 212, and

Vol. I., page 223), it is a constant tendency of Lineweavers to thicken the upper part of their snares until they sometimes have a quite sheet like appearance.

Nothing could be more interesting than a study of the life of these creatures thus doomed to perpetual darkness in the bowels of the earth.

Their Food.

To a great extent their natural history must be a matter of speculation. That they make snares we know, and the character of those snares is without exception the most rudimentary spun by spiders, namely, a series of intersecting lines drawn from point to point. The fact that they make snares implies that there must be some creatures to be ensnared upon which they feed, and these creatures must, of course, be less in physical power than themselves. What insects form the basis of their food? Among the insects occupying similar American caverns are minute delicate mites, and Professor Packard conjectures that these, together with young Poduræ, may form a portion of their food.

Moreover, these cave araneads have sufficient vitality to propagate their own species. The old story of wooing and mating goes on in these regions of unbroken darkness just as it does in the sunlight and among the flowers and shrubs above. Mother love is not quenched by the endless gloom, and the tiny creature of the cavern spins and cares for its tiny cocoon just as does its more favored sister of the sunlight. The number of eggs within the cocoons is very small in some species, according to the statements of Professor Packard from two to five in Anthrobia, but in others the excess of life is quite sufficient (there being thirty or forty in the cocoons of Nesticus pallidus) to justify the inference that the chief supply of food for these cave spiders is drawn from their own numbers. In other words, they feed upon each other, and these Plutonic children of Arachne must continue their generations largely by cannibalism.

The influence of this mode of existence upon the structure and senses of these cave spiders will be considered elsewhere. It may be fitting, however, to add here an experience which throws some light upon the manner in which the animals might have been originally conveyed to these sub-

Origin of Cave Fauna.

terranean abodes. One summer while examining the limestone caverns in central Pennsylvania, located among the Allegheny Mountains, in what is known as the Scotch Valley, not far from the city of Altoona, I stood in the channel of a small stream in the neighborhood of Sinking Spring. Looking forward, towards the source of the stream, I saw the waters flowing down towards me, but gradually diminishing, with no apparent reason, until, near the spot where I stood, the stream dwindled to a mere thread and disappeared. It produced a curious sensation to stand thus in midchannel and see a flowing brooklet lost to one's sight before it reached the point where, under ordinary circumstances, it would have swept around the feet of the observer. The secret, however, was readily explained, for the whole section underneath

the bed of the stream is hollow and connected with the cavernous formation which characterizes the entire region. The water could be seen trickling down through the pebbles, and, by putting the ear to the ground, it could be heard dropping into the depths beneath.

Sporting on the Brink.

I observed that, in the neighborhood of the place where the threaded points of the stream thus sunk out of sight, numbers of little spiders were running about, some of them probably seeking food, but others appearing simply to be enjoying themselves like other young animals at play. These spiderlings seemed to be chiefly Lycosids, though some of them were probably the young of Agalena nævia, and, it may be, other species. They were running over the bed of the brook and hiding under the pebbles at the very spot where the water sunk out of sight; and it immediately occurred to me that nothing was more likely than that numbers of these spiders might be, and indeed had been, caught in the falling waters and carried down into the cavern underneath.

They have sufficient vitality to endure, without much injury, such a transition, but what would befall them when they reached their subterranean prison? Would these lost spiderlings make themselves at home and proceed to adapt themselves to their new environment? Many spiders, we know, love gloomy abodes, dens in the earth and shaded spots. They are nocturnal creatures, and go out at night to seek their prey. It would not be so very difficult for creatures reared under these circumstances to survive in total darkness, if only the means of livelihood could be found.

Effects of Cave Life.

But what would be the influence of environment upon these unwilling prisoners of the cave? How long would it be ere change in life compelled a change in structure? To what degree would that structural change occur? What forms are those most likely to survive such a transition? What species were the ancestors of our cave fauna? As far as known, those now extant appear to belong chiefly to the Theridioids, and their habits indicate the rudimentary form of spider life which is possessed by that family. Have all other species accidentally introduced into caves perished, except these delicately organized Retitelarians. Or shall we think that some species have gradually been transformed by the influence of their strange new life into those peculiar forms which now inhabit our caves?

Tubeweavers: A Paradox.

Judging from the well known habits of surface species, I would have expected and predicted that the prevailing fauna of caverns would have belonged to the Tubeweavers. Many species of this tribe live in corners, crannies, dark rooms, under stones, rocks, fallen trees, and like locations, from which light is largely excluded. Others secure their prey during night hours, although in this respect they are not peculiar from other tribes. The transfer from such a habit to a life within a cavern to which no light ever penetrates,

or which is but dimly illuminated, would seem to be less decided transition than in the case of many other genera. Nevertheless, the facts at present within possession of araneologists appear to indicate that the Tubeweavers have secured no permanent representatives among our cave fauna, this position being wholly occupied by members of the Retitelariæ. We have thus presented the curious fact that the species which by natural tendency appear to be best adapted to survive cavern conditions have been thoroughly eliminated or excluded.

CHAPTER VI.

COMPARATIVE COCOONING INDUSTRIES.

In this chapter I propose to review the cocooning industry of spiders as given in the last two chapters. In order to compare those methods of spinning the cocoon which characterize the genera of the several Tribes, I shall first describe in detail the manner in which Argiope cophinaria constructs her cocoon.

No single point, in my study of aranead spinningwork, has been a subject of more prolonged attention, and the cause of greater disappointment, than the mode practiced by the mother spider in overspinning and protecting her eggs. I strongly desired to see and describe the entire process on the part of at least one species, and, if possible, of several species. To this end I have year after year sought the natural sites at the cocooning time, and have kept watch, day and night, personally and by proxy, over numbers of gravid females confined within various boxes, jars, and other objects. I have tried to make the artificial conditions as favorable and natural as possible. Notwithstanding all the patience and ingenuity expended upon the observations, I am compelled to confess that the secretiveness of the female spider has been a fair match for my curiosity.

It is true that I have made many observations of the process of cocoon making at various points of the same, ranging all along from the first stages to the last. Yet I have never had the opportunity to see the entire process in any one species or genus, and, indeed, there are one or two points of the process which I have never seen in any species of any family. Nevertheless, I have observed nearly all the stages of construction in the case of Argiope cophinaria, and am therefore able to describe methods of spinningwork which, if they have heretofore been observed, have at least never been made known. The description of this industry will form the first section of the present chapter. Thereafter will be introduced some conclusions which a comparative view of cocooning industry has suggested to my mind.

I.

I observed one of my Argiopes, which I will distinguish as Prima for convenience' sake, shortly after she had left her snare upon an ampelopsis vine, crawling along stems under leaves with that uneasy demeanor which commonly indicates that the crisis of maternity is near. I placed her in

a trying box, and sat up with her until a late hour at night. During a considerable portion of the evening she moved back and forth in the box, spinning lines from one side to the other, and finally settled in one corner as though to rest. Thereupon I retired.

FIG. 192. Argiope cophinaria immediately after ovipositing. The spider is beneath the mass of newly laid eggs which she has just begun to overspin.

Next morning at 5.35 o'clock I visited the box, and found that the eggs had just been laid, and enclosed within their first thin silken pouch. A rectangular patch of yellowish white silk was swung to the cross lines spun the night before. Immediately beneath this was a tuft of brownish silk, that enclosed a tiny silken dish three-eighths of an inch in diameter, which rested against the top piece, with its concavity downwards. Against this dish Prima had oviposited her eggs, forcing them upward evidently as she hung in position beneath. At the time of my observation this was the position of affairs. The eggs were in a hemispherical mass, and hung downward, with no enclosure except the white silken pouch which is the first covering the Orbweaver usually places upon the eggs. (Fig. 192.)

Argiope cophinaria.

The mother remained for a few minutes beneath her eggs, and then began spinning the brown covering. Her back was downwards, and her feet curved upwards, holding to the supporting lines or to the edges of the top piece. Gradually moving herself around in a horizontal plane, she spun the threads upward against the top part of the egg mass, attaching threads to the overhanging edges of the flossy tuft already described. This action and position are represented by Fig. 193. At six o'clock and eight minutes she rested for a few moments, and at that time her work presented the appearance represented at Fig. 193.

The Brown Pad.

FIG. 193. Argiope spinning up the brown padding around her eggs. The hind leg is shown drawing out the silk, and the bunch of loops is shown against the cocoon.

Unfortunately, she was much hampered by having lost two legs, which happened to be the most important for her present purpose, as one of them was the hind leg used in spinning, and the other the first leg, which is the guide, if I may so say, of the spider's motion, being continually used to feel the way as she progresses, and pilot her into the proper course. Thus mutilated, Prima probably was twice as long accomplishing her task as she otherwise would have been, since she only had one leg with which to draw out and pack the silk as it issued from the spinnerets. Nevertheless, she managed affairs very handsomely.

During this and the earlier part of her weaving it seemed to me that the silk escaped from the posterior pair of spinnerets alone. It came out as white silk with a little yellowish cast in it, bearing a pretty gloss. The spinnerets were widely flared, and the silk issued in several filaments. The hind leg was thrown upward as the spider moved and seized these filaments with the foot, apparently using all the spines from the claws upward to the tarsal joint, and even part of the metatarsus. The thread was carried away from the abdomen rather slowly toward the cocoon. (Figs. 194 and 195.[1]) At the same moment, also, the abdomen approached the cocoon without touching it. Between the spinnerets and the spider's foot the silken filaments were stretched taut (Fig. 196), and after the first gentle motion of approximating the cocoon the abdomen was swung in the opposite direction; that is, away

Use of Hind Leg.

Fig. 194.

Fig. 195.

Figs. 194, 195. The action of Argiope in drawing out silk with the spinning legs. The alternation of the legs appears by comparing the figures.

from the foot, so that the intervening stream of silken threads was drawn out to a considerable distance, sometimes as far as three-quarters of an inch. In the meantime that portion of the outspun threads between the spider's foot and the point at which the line was attached to the cocoon, of course, relaxed and doubled up into a curled loop of several strings; and in this condition it was when the leg finally touched the cocoon. (See Fig. 196.) With a quick movement the thread was slipped off the leg and pushed into the mass of spinning-work already accumulated. It at once adhered, though no viscid material appeared to be intermingled therewith, and added its flossy loops to the mass that had been spun before. The position of the leg and spinnerets during this action is represented at Fig. 197.

Laying on the Loops.

[1] These two figures were made from a second spider with full complement of legs.

At occasional intervals the spinnerets were laid against the cocoon and held there a brief space, while the spider pushed them into the mass, attaching her thread precisely after the manner described as customary when she is making a dragline anchorage. (See Vol. I, page 61.) This, of course, held to its position and prevented the raveling of the thread already accumulated. I was somewhat surprised that more use was not made of the spinnerets, as I had conceived the idea that they were continually employed to beat down and pack the cocooning material, after the fashion of the long spinnerets of Agalena nævia and most of the Tunnelweavers. On the contrary, the spinnerets rarely touched the cocoon, at this stage of the work at least, and the entire process of packing was accomplished by the pressure of the leg alone.

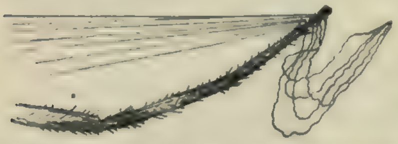


Fig. 196. The hind leg of Argiope stretched out and drawing the ray of threads.

Packing.

It seemed to me also that the palpi had something to do in packing the flossy loops as they gathered upon the mass. At all events, they were always held doubled under, as represented in some of the figures, and were moved continually in a way that gave me the idea that the spider appeared to be kneading the silk with them. Perhaps the reason of this was to prevent the palpal claw from fastening in the threads, for care was also taken to bend the claws of the feet well under, as though to guard them from that annoyance.

Equalizing the Output.

In this manner the spider proceeded, working her silken mass downward, and gradually bringing it to a tolerably regular, oval shape. This was done entirely by so regulating the discharge of the silk and the application of it to the cocoon that the surface was kept even and regular. I cannot positively say upon what principle this was accomplished, but I was made aware of the fact that the aranead continually changed her course as she moved around the cocoon, describing a complicated series of convolutions. This was shown strikingly in the following way: In order to make exact drawings of the various attitudes of the spider while spinning, I drew a number of outlines of the cocoon at various stages upon blank paper, and waited to insert the various parts, as the legs, palps, spinnerets, etc., in proper sequence as the spider would from time to time reappear at the same point. My idea was that on one round I would sketch one leg, on another the next leg, and so on, supposing that Prima would appear substantially at or near the same place a number of times during her numerous rounds, and thus I would have many opportunities to catch her in the same attitude.

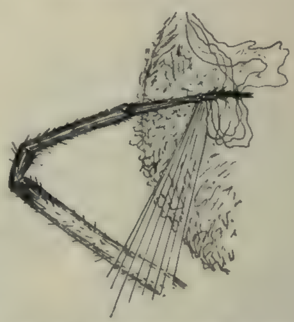


Fig. 197. Manner of forming and laying on the loops.

Winding the Thread.

I was, however, made painfully conscious of the fact that she very rarely presented the same attitude consecutively. As she made her rounds she would almost invariably appear at a different point each time, now above, now below, now at the middle, and anon emerging from beneath and coming back upon her course. (Figs. 198, 199.) It thus became a matter of much greater difficulty to secure good drawings than I had calculated upon, although I eventually satisfied myself. But in the meantime it appeared that by this peculiar mode of progress the spider equalized the distribution of spinning material upon her cocoon, and prevented any part of it from growing disproportionately to other parts. The method was not unlike that of a person winding a ball of silk or wool from a skein of thread.

One cannot but recognize in this action a manifest purpose, however directed or originated, to build up her cocoon mass symmetrically, and cover all parts thereof equally. While thus engaged in spinning, the feet

FIG. 198.

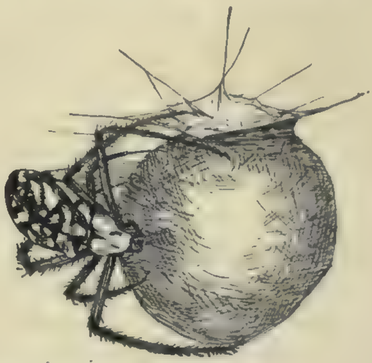


FIG. 199.

Equalizing the output of thread.
FIG. 198. Position below the cocoon. FIG. 199. Position above on next round.

were extended upwards, grasping the shoulder of the flossy mass or the edges of the supporting top piece. As the mass increased, the legs, of course, were stretched out further, but at no time was there any difficulty in enclosing the entire structure within the long legs of the animal.

Brief Rests.

Brief rests were taken at long intervals of time, but the periods were very short, three or four minutes as a rule, rarely more. The spinning continued without intermission, sometimes more slowly and again more rapidly. At seven o'clock and eight minutes the cocoon appeared to be completed, as far as its general shape and size were concerned, but the spider continued working on it until ten o'clock and fifteen minutes, when I was compelled to cease my observations.

During the last three hours the spinnerets were more frequently squeezed against the cocoon, as though to pack the mass and fasten the threads more closely. The filaments now, instead of being bent upon the surface

in the form of flossy loops of curled thread, seemed to be laid down as straight lines. As a consequence the surface after spinning did not show the flossy appearance, for example, of a bit of cotton wool, but rather the smooth and compact appearance of a spool of closely wound sewing thread. Not that the cocoon thread was wrapped quite as closely as the spool, but in a general way it presented that appearance. This effect was promoted by the use made of the leg, which was laid flat along the cocoon, and the last two joints pressed against it, thus serving to compact the threads.

FIG. 200. FIG. 201.

FIGS. 200, 201. Epeira strix enclosing her eggs within silk floss. (After Emerton.)

When I returned at twelve o'clock and ten minutes, work upon the cocoon had ceased, and the spider was putting in the finishing lines of the maze of interlacing threads within which the cocoon of this species is ordinarily suspended. I was somewhat surprised, however, to find that no change had occurred in the exterior appearance and character of the mass since I had left it. I had supposed that some kind of a varnish would be laid upon the surface, having the idea that perhaps some modification or degree of the material which composes the viscid beading of the snare would be used to cover in the interspaces of the silk on the exterior, thus making it partly weatherproof. But Prima's cocoon showed only the glossy white silken surface with a little tinge of yellow, and no trace of anything but the original silk as it had issued from the spinnerets.

This was in sharp contrast with a cocoon in the trying box just above, which had been made by another Argiope two days before, but whose making I was not able to see. I had watched it late into the night, and in the morning when I came to look at it the cocoon was entirely finished and the spider engaged in weaving around it its protection of netted lines. But the surface of the cocoon had been treated in the ordinary way, and presented the customary yellowish brown tint, had the hard, dry, parchment like feeling, and gave out the crackling sound which is almost invariable in cocoons of this species. I have little doubt that it is treated in some peculiar way, immediately after completion, in order to produce this effect, but as yet the method is unknown to me.

FIG. 202. Female Theridium tepidariorum finishing a cocoon. Other cocoons hanging in the nest.

The spider Prima probably began to make her cocoon shortly before five o'clock of the morning, and must have continued weaving at least until half past ten. She was therefore engaged five hours, at the least,

in work. But as her mutilation prevented her from making the ordinary speed in spinning, this cannot be taken as a fair test of the time which an able bodied spider would require for the same work. In point of fact, I think that half the time, or from two hours to two and a half, is the period commonly taken by the female Argiope cophinaria to construct her beautiful and intricate cocoon. I had the opportunity, since making the above detailed observations, to see other Argiopes spinning their cocoons. The process is always the same, except that those spiders which (unlike Prima) have both their hind legs, use them alternately in drawing out and packing the spinning stuff.

Time Spent in Weaving.

II.

Without entering into details as fully as with Argiope, we may state generally the methods of cocoon construction practiced by other species and tribes. This will give sufficient material for comparison. The same mode of weaving is used by Epeira and all other Orbweavers whose habit in this regard is known to me. Mr. Emerton[1] gives a brief description of the manner in which Epeira strix weaves her cocoon. She touches her spinnerets as in Fig. 200, drawing them away at a short distance, and at the same time pressing upwards with the hind feet, as in Fig. 201. Then she moves the abdomen a little sidewise and attaches the bands of threads so as to form a loop. She keeps making these loops, turning at the same time, so as to form a rounded bunch of them.

Epeira. Theridium

Of the Lineweavers, I have seen Theridium tepidariorum engaged in overspinning her eggs. Fig. 202 represents this spider in the act of putting the finishing touches upon the outer case of one cocoon, while two others are hanging within the intersecting lines of her snare, from one of which a little brood of spiderlings has already escaped. The cocoon was suspended by a stout thread to the thickened mass near the top of the web, upon which the mother held with one long fore leg while she clasped and revolved her cocoon with the other legs. The spinning material was drawn out and laid on in loops as described at length of Argiope.

The process of making a cocoon, as practiced by the Speckled Agalena, was observed in the case of a female confined within a glass jar. A leaf was laid against the inner side of the vessel as a suitable object upon which to place the cocoon should the mother be inclined to use it. She presently availed herself of the opportunity, and wove upon the leaf a cocoon of the ordinary sort. I did not observe the whole process, but saw the finishing. The silken rug had

Making Agalena's Cocoon.

[1] "Habits and Structure," page 101.

first been spun upon the leaf, within which the egg mass was oviposited. Over that the external blanket was woven, and when my observation began the mother was engaged upon this.

The method of proceeding did not differ from that of other species and tribes in like work. The spider grasped the margins of the cocoons with the claws of her fore feet, which she continually moved around the margin as she spun. The third pair of legs, and occasionally one of the fourth, were also used for grasping the cocoon and moving the spider's body. The remaining fourth leg, and sometimes both the hind legs, were used for drawing out the spinning threads. As the spider thus swung around her cocoon, heavy filaments of silk were extruded from all the spinnerets, which were opened up and somewhat elevated. The long jointed third pair, particularly, was constantly lifted up and dropped, as though beating in the silken tissue, after the manner described in the case of Argiope cophinaria when making her silken shield. (Vol. I., Chapter VI., page 100.)

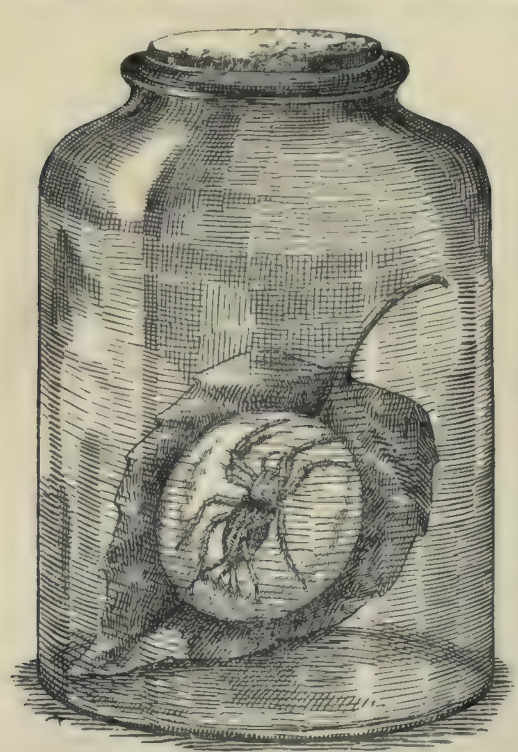


Fig. 203. Agalena nævia engaged in covering her eggs; use of the long spinnerets.

We may confidently assert that the Territelariæ form no exception, for I have fully observed their mode of spinning the material which corresponds with the silken cocoon. The silken rug on which our great Tarantula rests, the tube of the Purseweb spider, etc., are almost certainly woven precisely as is the cocoon of those species; and, if so, the Tunnelweavers spin their cocoons as do other tribes.

Turning to the Wanderers, we have in the case of the Lycosids an example, to which I have heretofore referred (Vol. II., page 144), of the manner in which Lycosa fabricates her round cocoon. She first weaves a circular patch, which she afterwards forms into a hollow sphere surrounding her eggs. The mode of equalizing the spinning thread is as follows: The feet clasped the circumference of the cushion, and the body of the animal was slowly revolved. The abdomen, greatly reduced in size by the extrusion of the eggs, was lifted up, thus drawing out short loops of silk from the extended spinnerets, which, when the abdomen was dropped again, contracted and left a flossy curl of silk at

Lycosa.

the point of attachment. The abdomen was also swayed from one side to another, the filaments from the spinnerets following the motion as the spider turned; and thus an even thickness of silk was laid upon the eggs. The same behavior marked the spinning of the silken rug or cushion in the middle of which the eggs had been deposited. It will thus be seen that the entire process of forming a cocoon, as wrought by Lycosa, resembles in every particular the mode practiced by Tubeweavers and substantially by Orbweavers.

Saltigrades.

So also is it with the Saltigrades. I have observed Phidippus rufus spinning its cocoon, and she proceeds after the same general method. A Saltigrade mother is represented at Fig. 205, as sketched in the act of cocoon making. The diverging lines of silken spinning stuff are there seen proceeding from the spinnerets, while the abdomen is lifted up at a considerable incline, and the feet clasp the borders of the cocoon. As this Phidippus revolved she alternately dropped and elevated the abdomen, while the silken loops thus formed curled down into the mass already spun and were further beaten in by the spinnerets and legs. It thus appears from personal observation of typical species in all the tribes, with the exception of the Laterigrades, that the manner of outputting the spinning stuff while weaving cocoons is practically the same. The only difference observable is confined to the use of the spinnerets in beating down the outspun threads, these organs being more freely used for this purpose among the Tubeweavers and Tunnelweavers, who possess long pairs of superior spinnerets, than among others.

FIG. 204. Phidippus rufus spinning her cocoon cover.

III.

General Spinning Method.

Proceeding now to a comparative study of the cocooning industry of spiders, we observe, first, in view of the preceding sections of this chapter, that the general method of spinning the cocoon, as it has been observed in representative species of all but one of the tribes, is substantially the same.

1. That method consists in drawing out thickened lines from the spinnerets while the body is slowly revolved around the area to be occupied by the cocoon; or, as in Theridium, the cocoon is revolved upon a suspensory line. The loops thus drawn out are about the length of one-half the distance between the surface points to which the cocoon is attached and the point to which the spinnerets are raised by the elevation of the abdomen. As the spinnerets drop after their elevation, the thread relaxes, curls, and thus a soft loop of curled thread is left upon the growing cocoon mass. In some cases this is beaten down by the feet and spinnerets, or spread over by them as a plasterer spreads mortar, until the cocoon

case is quite hard. In others, it is left in the flossy condition in which it is originally spun.

Composition of Cocoons.

2. While the general method of spinning out the material, as above described, is that which prevails among all Tribes, the composition of the cocoon, or general plan of architecture, may be properly separated into three distinct modes. In the first the eggs are made the centre of operations, being first laid upon a circular patch, covered by a mass of continuous floss, and thereafter usually enclosed within a seamless case of thickened spinningwork. The protection to the eggs is thus a single and unbroken covering. This method prevails among Orbweavers and Lineweavers.

In the second method the cocoon covering is spun in two parts. There is first woven a sheet to receive the eggs, and after the eggs have been overspun and swathed a second and similar sheet is made as an outer covering. This method is the prevalent one among Tubeweavers, Saltigrades, and Laterigrades.

Cocoons classified under the second mode may be subdivided into two well defined groups, viz., first, those in which the covering consists of pure silk; and, second, those in which the silken covering is strengthened or padded by bits of gnawed bark, sawdust, and various light chippage, daubs or pellets of mud, and sometimes by an entire coating of clay. This mode of providing an armor of extraneous material is most prevalent with Tubeweavers, although it occasionally appears among Orbweavers. Sometimes the armor or upholstery is itself covered over with an exterior silken case, as with Agalena nævia; but again it forms the outer casing or plaster, as with Micaria limicunæ and Clubiona tranquilla.

The third special mode is that which prevails, one may say almost universally, among the Citigrades, and which is probably practiced by the Tunnelweavers also. It consists in spinning a single sheet, within which the eggs are deposited, which is subsequently pulled over the egg mass, and pinched by the jaws into a globular covering, the selvage of which is united with sufficient firmness to adhere until the spiders are ready to leave the cocoon, when the seam yields sufficiently to allow the escape of the inmates.

Disposition.

3. A third point of comparison is as to the disposition of the cocoon by suspension or attachment. We may divide the cocoons of all tribes broadly into two classes, (I.) hanging cocoons and (II.) fixed cocoons. The hanging cocoons may be subdivided into those (1) which are suspended within the snare and (2) those which are suspended or attached outside of or near the snare. The latter class may again be divided into (a) those which are suspended with external protection and (b) those which are suspended without external protection.

Of spiders that hang their cocoons within the snare, the Orbweavers have a number of representatives, as especially Epeira labyrinthea, Cyclosa

caudata, Epeira bifurca, Uloborus plumipes, Epeira basilica. Among Lineweavers may be found most of the genus Theridium, as T. tepidariorum and T. studiosum, Steatoda borealis, the various species of Erigone and Argyrodes. The Tubeweavers have numerous representatives, as it is a quite general habit for the species of this tribe to deposit their cocoons within the tubular portion of their snare, which forms also a nest. Among the Territelariæ Atypus has the same habit, so also have the South American species described by M. Simon, and the immense creatures known as the Mygalidæ appear also to nurse their cocoons within their burrows. This is the custom of our well known Trapdoor spider, Cteniza californica. Among the snareless Wandering spiders, Citigrades, Saltigrades, and Laterigrades, of course, there are no representatives of this group.

Within Snares.

Spiders that hang their cocoons outside their snares are largely represented among Orbweavers. Indeed, this may be said to be a general habit, as most of such genera as Epeira, Argiope, Zilla, Acrosoma, Tetragnatha, Nephila, Meta, and Hyptiotes spin their cocoons separately from their snares. The habit prevails also among Lineweavers, as is illustrated by the habit of Theridium frondeum in swinging her pretty little orange colored cocoon to the under sides of leaves and the surfaces of rocks. Among Tubeweavers, Segestria canities of California suspends her string of clustered cocoons outside her nest, although she does subsequently spin a tubular cell alongside the cocoon string, and there dwells while completing the process of cocoon making and while the young are being reared. Tegenaria medicinalis also suspends her cocoon most frequently to some object, as a log, or beam, or branch, outside of her snare, although sometimes she hangs it to the lower portion of the sheeted pouch itself, or even interweaves it within the fibres of the sheet. Among Citigrades, the Southern species, Pucetia aurora, and all the known species of the genus Dolomedes swing their cocoons not, indeed, outside their snares, since they are Wandering spiders, but in special nests prepared for the purpose.

Outside Snares.

The spiders which attach their cocoons to fixed surfaces, instead of swinging them among interlacing lines or suspending them within their snares, are numerous and have representatives among nearly all tribes. Such is the habit among Orbweavers, in most of the genera, as Epeira, Zilla, Gasteracantha, Nephila, etc.

Fixed Cocoons.

Among Lineweavers, species that dispose of their cocoons in this way appear to be rare, although such a European species as Theridium denticulatum has this habit.[1] Among Tubeweavers, the great mass of spiders of all or nearly all the genera fasten their cocoons to various surfaces. These plano convex objects may be seen in the autumn, for the most

[1] Staveley, "British Spiders," page 147.

part, attached to the under side of stones or spun within rugosities of the bark of trees. They have often bright colors, and are found covered with mud. Among Saltigrades and Laterigrades, all species appear to have the habit of thus disposing of their cocoons.

IV.

4. A fourth point of comparison is the method of protecting cocoons. When we come to consider the modes of protecting cocoons, we find much variety, and the various methods well represented among all Tribes, modified by differences in habit characteristic of the groups represented. The chief modes of protection are, first, by lines, within which the cocoons are spun and which form an interlacing barrier of threads around them. This mode has many representatives among Orbweavers and Lineweavers; is occasionally represented among Tubeweavers, as with Dictyna and Segestria; occasionally among the Citigrades, as Dolomedes and Pucetia; but is unknown among Saltigrades and Laterigrades.

Protection. 1. By Lines.

The second mode of protection is by leaves, which are drawn over the cocoons. This is either done by attaching the cocoon to a single leaf and then curling the edges thereof around it, or by forming a sort of bower of several leaves united at the points and edges, and spinning within this cavity a maze of interlacing lines, within which the cocoon is hung. This method of protection is well represented among Orbweavers. Among Lineweavers it is seen in our Theridium differens, and in certain European species of Theridium, as T. nervosum, T. riparium, and T. lineatum. Among Tubeweavers it largely prevails, Agalena, at least, practicing this method. Dolomedes represents the Citigrades, making a beautiful bower, within which her cocoon is hung. The Saltigrades frequently thus protect their cocoons; and among Laterigrades, Thomisus, Sparassus, and Philodromus.

2. By Leaves.

The third method of protection is by silken tents and tubes. This is sparingly practiced among Orbweavers. Among Lineweavers, as far as I know, it is only used when the silken tent is enclosed within an outer covering of leaves. Among Tubeweavers it has a wide use, Herpyllus, Ariadne, Drassus, Clubiona, and others of like spinning habit practicing it probably without exception. I know of no Citigrades that thus protect their cocoons, unless we consider the burrow and home as a cocoon tent or den, and it certainly does serve that end. But among the Saltigrades the habit is general, Phidippus, Attus, Synagales, Synemosina, and all known genera protecting their cocoons with an outer silken cell, within which the mother dwells. Among the Laterigrades, Thomisus and Sparassus have the same habit.

3. By Tents and Tubes.

The fourth method of protection is by an armor of extraneous ma-

terial, such as insect débris, plant chippage, sawdust, sand, and mud. Among Orbweavers that practice this method of armoring their cocoons are Epeira cinerea and Cyclosa caudata. I know no American representative among Lineweavers, but there are no doubt such, as some English species have the habit. Among Tubeweavers the habit is most common. The cocoons of Agalena are frequently found upholstered with sawdust and scrapings from bark, or bits of chippage plucked from surrounding vegetation. Clubonia frequently plasters over with mud her beautiful white cocoon. Micaria limicunæ completely encloses her little egg sac within a thick ball of mud. Others of this family make a spherical ball, composed of miscellaneous débris, within the heart of which the cocoon is protected. The habit appears to have secured no lodging among the Citigrades and Saltigrades, but is practiced to a limited extent by some Laterigrades.

4. By Armorage.

A fifth mode of protection is suspension within the snare. Some Orbweavers have this habit, as the Labyrinth spider, the Tailed spider, and others. Many Lineweavers in the genera Theridium, Argyrodes, etc., thus protect their cocoons. Indeed, it is the well nigh universal method in this tribe. Among Tubeweavers the custom prevails, that is, if we consider the tubular dwelling cell as a portion of the snare. The same remark applies to the Territelariæ, as Atypus, Cteniza, and the large Mygalidæ, who protect their cocoons within their tubular dens, as do the Saltigrades also. The Citigrades and Laterigrades, of course, have no such habit, as they are not snare making tribes, although they make a cell or den to contain and shelter their cocoons.

5. Suspension in Snares.

The sixth method of protecting the cocoons is by sentry, that is to say, by watching on or near the cocoon—an action to which the term "brooding" has sometimes been applied. Of this method, the Orbweavers have representatives among the genus Epeira, as, for example, our American Epeira cinerea and several European species, to which may probably be added Cyclosa and Uloborus and others of like habit. Nearly all Lineweavers may be considered as practicing this method. At all events, their cocoons are swung within their snares and the mothers are frequently found embracing them and vigorously resist any effort to deprive them of the treasure. Among Tubeweavers, many genera keep faithful watch on their cocoons, as Agalena, Herpyllus, and many of the Drassids. The Tunnelweavers, who retain their cocoons within their burrows, may be regarded as keeping sentry upon them, and the habit is quite general among Saltigrades and Laterigrades.

6. By Sentry.

The seventh mode of protection is by portage, that is, by carrying the cocoons within the jaws or attached to the spinnerets. I know no representative of this habit among Orbweavers. Among Lineweavers the habit is universal with Pholcus, who carries her cocoon beneath her jaws. At least one European species of Linyphia and one of Theridium have

the habit of deporting their cocoons, like a Lycosid, tied to her spinnerets. No Tubeweavers are known to carry their cocoons. Among Citigrades the habit is universal with Lycosids, and prevails with Dolomedes until about the time when the eggs are ready to hatch, when she discards the cocoon and deposits it within a prepared nest. Ctenus probably resembles Dolomedes in this peculiarity. The Territelariæ appear to carry their cocoons, although not to the same extent as the Lycosids, owing to marked difference in mode of living. None of the Saltigrades or Laterigrades are recorded as deporting their egg sacs, except Heterapoda venatoria, who does so occasionally. The eighth method of protection is sheltering cocoons beneath stones, bark, etc. This is in use among all the tribes, with the probable exception of the Tunnelweavers.

7. By Portage.

8. Shelter of Stones.

The ninth and last mode of protecting the cocoon is by simple suspensory lines. This seems to be the simplest form of protection, and is doubtless effective against such enemies as would be apt to find the eggs if placed upon a flat surface, but who would not venture to assault them if compelled to creep along a fragile thread. Among Orbweavers few species are known, but there are some European representatives of this habit. Cyrtarachne may be considered as thus providing for her cocoon. Among Lineweavers there are a number of representatives, our most conspicuous American one being Theridium frondeum. Of the Tubeweavers, Tegenaria medicinalis, at least occasionally, thus disposes of her cocoons; and among European species are Agalena brunnea and others that hang their flask like egg sac from heather and other plants by means of a foot stalk. The other tribes, as far as I know, do not swing their cocoons free in this manner.

9. By Suspensory Lines.

The accompanying table will show at one view the comparative prevalence of these various modes of protection among the tribes, as far as my observations and notes permit. It will be seen from this view that all the modes of protection, with the exception of portage, prevail among Orbweavers and Tubeweavers; that all the methods are represented among Lineweavers, although some of them appear to be faintly developed and sparsely represented therein.

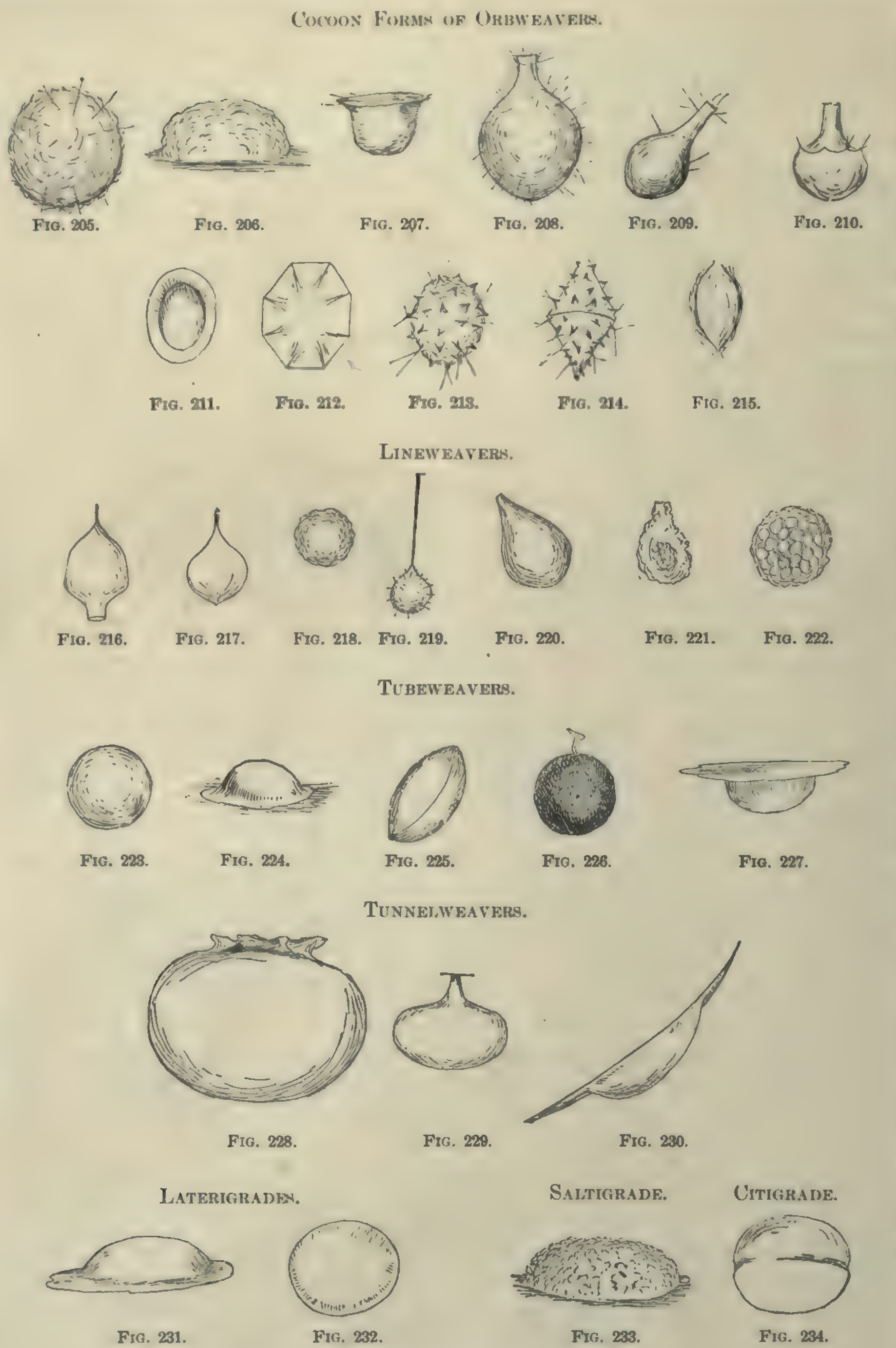
V.

5. A fifth basis of comparison is the form of cocoons. The greatest variety obtains among Orbweavers. Round cocoons, hemispherical or plano convex, pyriform, or stalked cocoons, with various modifications, as illustrated in the accompanying group, are the forms that commonly prevail among American Orbweavers. A comparison with the cocoonery of European and exotic Orbweavers, as far as they are known, shows that there is a substantial likeness between them and the American spider fauna.

Cocoon Forms.

TABLE SHOWING PREVALENT MODES OF PROTECTING COCOONS AMONG TYPICAL GENERA OF THE VARIOUS TRIBES OF SPIDERS.

	ORBWEAVERS.	LINEWEAVERS.	TUBEWEAVERS.	TUNNELWEAVERS.	CITIGRADES.	SALTIGRADES.	LATERIGRADES.
1. By surrounding lines . . .	Epeira. Argiope.	Theridium. Argyrodes.	Segestria. Dictyna.	. . . .	Dolomedes. Pucetia.	. . . .	. . . .
2. By leaves	Epeira.	Theridium.	Agalena (?).	. . . .	Dolomedes.	Attus. Other genera (occasionally).	Thomisus. Xysticus. Philodromus.
3. By tents and tubes	Epeira. Zilla.	Theridium.	Drassus. Micaria. Herpyllus, etc.	In home tube. Cteniza, Atypus (all species).	Lycosa (cells under ground).	Attus. Phidippus. All genera.	Thomisus. Xysticus. Philodromus.
4. By extraneous armor . . .	Epeira. Cyclosa.	Theridium.	Agalena. Tegenaria. Cœlotes. Micaria. Drassus. Clubiona.	. . . .	. . . .	. . . .	Thomisus (slightly).
5. In the snare	Epeira. Cyclosa. Uloborus.	Theridium. Argyrodes. Steatoda.	Segestria. Dictyna. (Many Tubeweavers.)	All species.	. . . .	(In home cell.)	(In special cell.)
6. By sentry	Epeira. Uloborus. Cyclosa.	Theridium. Steatoda. Linyphia.	Herpyllus. Ariadne. Drassus.	All species.	Dolomedes. Ctenus (?).	Attidæ. (In home tube.)	Thomisids (many species).
7. By portage	. . . .	Pholcus. Theridium. Linyphia.	. . . .	All species (probably) (occasionally).	Lycosids. Ctenus. Dolomedes.	. . . .	Heterapoda (occasionally).
8. Beneath stones, etc.	Epeira.	Linyphia (many genera.)	Agalena (and many genera).	. . . .	Lycosa (many species).	Most species.	Most genera.
9. By suspensory lines	Epeira. Cyrtarachne.	Theridium. Ero.	Tegenaria. Agalena.	. . . .	. . . .	. . . .	. . . .



Comparative map of aranead cocoon forms.

Next to Orbweavers, the Lineweavers exhibit the greatest variety of form. A round or ovoid cocoon is the prevalent form, but the pyriform is well represented in this tribe. Among Tubeweavers the almost universal form of cocoon is the plano convex or hemispherical. This results from the quite general habit of attaching the egg sac to the surface of some object. In some cases, however, Tubeweavers suspend within their nets a double convex cocoon; and, again, hang to the foliage or other surfaces a pyriform cocoon, as in the case of the European Agrœca brunnea. Among Tunnelweavers there is apparently but one form, as is indicated by the cocoonery of the few species known. This cocoon is a round ball and is in every respect like, or at least closely resembles, that of Citigrades.

The Citigrades also have apparently one form, a globular silken case within which the eggs are enclosed with little or no padding. In numerous species of Lycosa, Dolomedes, Ctenus, etc., this form prevails. Among Saltigrades, also, there is apparently but one form, a hemispherical or plano convex cocoon, attached to some surface, the case being enclosed within a soft, flossy, or thick netted covering of spinningwork. Among Laterigrades there is greater diversity than among the last three mentioned Tribes. But, for the most part, the cocoons consist of stiff hemispherical cases attached to surfaces of rocks and trees; occasionally, however, as in the case of Philodromus and some species of Thomisus, the cocoon is a double convex covering hung between leaves or twigs.

It is thus observed that the greatest variety and complexity of cocoons, as to form and structure, are to be found among the Sedentary tribes. The very greatest is in the Orbweavers, where the variety of form is remarkable. Next in order are Lineweavers, although it is possible that, if a wider study of this tribe were made, they might be found to approach more nearly the Orbweavers in this respect than we are justified at present in asserting. The Tubeweavers follow in order. The Territelariæ are classed ordinarily with Sedentary spiders, and many of the species fully justify this classification, since, like Atypus, they persistently dwell within their tubes. But they have also many of the characteristics of the Wanderers, and therefore we find their cocoons approaching those of Citigrades in simplicity of form.

Variety and Complexity.

In the comparative chart printed upon the opposite page I have tried to show at one view the typical forms of cocoons known to be made by representative genera of the various tribes. The following is the explanation of the chart: COCOONING FORMS OF ORBWEAVERS: Figs. 205, 206, Epeira; 207, 208, Argiope; 209, 210, Cyrtarachne; 211, Epeira labyrinthea; 212, Epeira bifurca; 213, Tetragnatha; 214, Uloborus; 215, Cyclosa caudata. LINEWEAVERS: 216, Argyrodes trigonum; 217, Theridium frondeum; 218, Steatoda and Theridium; 219, Theridium; 220, 221, Theridium; 222, Pholcus. TUBEWEAVERS: 223, 224, Agalena, Drassids; 225, Segestria; 226, Micaria limicunæ; 227, Tegenaria. TUNNELWEAVERS: 228, Mygalidæ, Eurypelma; 229, Atypus; 230, Nemesia. LATERIGRADES: 231, Thomisus, Xysticus, and many genera; 232, Heterapoda and others. SALTIGRADES: 233, Attus, Phidippus, and all genera. CITIGRADES: 234, Lycosa, Dolomedes, and all known genera.

The greatest general simplicity of structure appears among the cocoons of the Territelariæ, Citigrades, and Saltigrades, and the Laterigrades nearly approach them in this combination of simplicity and uniformity. It may be said that the tribe which shows the greatest simplicity and uniformity of cocoon structure is the Citigrades. The inference may therefore be drawn, that the greatest general simplicity of structure exists among the cocoons of those spiders which have them most closely under their personal care. It is manifest that in the case of Lycosa and other genera that attach their egg sacs to their spinnerets and carry them about until their young are hatched, there is less necessity for complex cocoonery to protect the enclosed eggs than in the case of Orbweaving spiders, like Epeira or Argiope, who hang their cocoons in the shubbery and leave them to the watch care of Nature alone.

Greatest Simplicity.

While this deduction is justified in the general view of the subject, it must be allowed that there are some exceptions which cannot well be explained. For example, the two cocoons which have absolutely the simplest structure are made by members of the Retitelariæ, as Pholcus phalangioides and Steatoda borealis. The egg bags of the latter species consist of a mere pinch of silk of such sparse weft that the eggs are plainly seen through them. Pholcus, who carries her cocoon underneath her jaws, while she hangs continually upon her snare, holds her eggs together by little more than a netted bag of scant spinningwork.

Exceptions.

One who examines, even casually, these various forms will see that they are determined substantially by the fact that the eggs, as they are extruded, naturally form a spherical or hemispherical mass, according as they hang free or are oviposited against some surface. Around this mass the protecting spinning stuff is woven, and then the external case. The addition of a foot stalk, more or less pronounced, appears to be determined by the act of suspending the cocoon during the weaving thereof, and the subsequent covering in and thickening of the suspensory cord so that the texture corresponds with the remainder of the outer case.

Origin of Forms.

The little conical or pointed processes which characterize several cocoons, as those of Tetragnatha and Uloborus, probably originated in the same way, namely, by the attachment of suspensory or broken threads to various points of the external surface, the points of attachment being thickened into little puffs or rolls or points of spinning stuff.

The introduction of extraneous material as an additional protection and the encasing of the silken sack in mud, as with Micaria limicunæ, is a habit to be accounted for altogether outside of the above; but the fact that these mud protected cocoons preserve the general form of the spinningwork which encloses the eggs, is undoubtedly determined by the same causes that regulate the shapes of all other cocoons.

VI.

Number of Cocoons.

6. A sixth basis of comparison is the multiplex cocoonery of certain species. The general habit among spiders is to make but a single cocoon at a time, and most females probably limit their maternal duty to the production of one egg sac. But there are numerous exceptions, which have been noted. Among Orbweavers the Labyrinth spider, the Tailed spider, the Basilica spider, and some others habitually produce several cocoons. These are not made contemporaneously, but are spun consecutively, with intervals of several days between each cocoon, so that the younglings will be hatched from the first brood while the last is yet freshly laid.

It is to be noted, also, that even those spiders that ordinarily limit themselves to one cocoon, as Argiope, under certain conditions, which are not fully understood, produce two or more cocoons. Epeira, when specially nourished, is said to produce several. The fecundity of the spider may therefore be said to be subject to variation, and the disposition to multiply cocoons is dependent, more or less, upon the fecundity.

Among the Retitelariæ numerous species are found spinning several cocoons, the most familiar example being Theridium tepidariorum and Latrodectus. The Tubeweavers also have some remarkable representatives of multiplex cocoonery, as, for example, certain species of Dictyna and Segestria. The cocooning habits of the Territelariæ are so little known that one cannot speak positively, but it is probable that no Tunnelweaver makes more than one cocoon.

Among the Wandering spiders the single cocoonery which characterizes the Tunnelweavers is the rule. I know no Saltigrade and no Laterigrade that produces more than one cocoon, although of the former Staveley says that Epiblemum scenicum makes one or two, and of the latter that Philodromus cæspiticolis deposits two flattened cocoons in a large nest.[1] Among Citigrades I know no species except Pucetia aurora; this spider produces at least two cocoons, that are concealed within a little nest of crossed lines, very much after the fashion of that constructed by Dolomedes. No doubt, however, a wider knowledge will compel us to include other species in this group.

This summary of facts points to these conclusions: First, that the three Tribes which are by especial eminence Sedentary possess the greatest number of species that make more than one cocoon. Second, that the three Tribes that are conspicuously Wanderers make but one cocoon, with rare exceptions. Third, that the Tunnelweavers, whose habits sometimes approach one group and sometimes another, but in the matter of cocoonery resemble the Citigrades, as regards multiplex cocoonery are to be classed with the Wanderers, apparently limiting themselves to a single egg sac.

[1] "Brit. Spiders," pages 57 and 85.

CHAPTER VII.

MATERNAL INSTINCTS: MOTHERHOOD.

In the chapters immediately preceding I have described the various devices and forms of spinning industry prompted by maternal instinct for preserving offspring. Apart from this—the mere industrial or architectural expression of motherhood—there are some facts in the natural history of the maternal habit which may perhaps best be considered in a separate chapter. Such, for example, are the motives which regulate the choice of a cocoon site; the methods of ovipositing; the measure of maternal purpose as taken from the complexity, isolation, or vigil of the cocoon; the causes regulating the number of cocoons and eggs; the motive controlling the armoring and mud plastering of cocoons; brooding the egg nest; the degree of and conditions limiting the maternal anxiety for the eggs; and the intensity and intelligence of the maternal sentiment. These are points of the greatest interest to all naturalists, and are well worthy of a far more extended and philosophic treatment than I feel competent to give. But it may be permitted me at least to open the way.

I.

Cocoon Sites.

The sites which spiders choose for their cocoons are, of course, largely determined by their habitat. The cocoons will always be found near by the locality in which the mothers have lived. Although some of them do occasionally move from their native centres, the migration is, as a rule, extremely limited; and Orbweavers, indeed all Sedentary spiders, may be considered as practically spending their lives within the narrow compass of the spot where they chance to pitch their first snare.

The favorite sites of Orbweavers are bushes, low trees, grass, weeds, the angles of walls in the neighborhood of houses and outhouses, and like situations which afford them facilities for hanging their snares. They are frequently exposed to the full blaze of sunlight; some species appear to love the most open exposures in woodlands; others, again, shun the sunlight and are found in woods and forests, in obscure corners, hollow trees, clumps of underbrush, and even, as in the case of Meta, in caves. They hang their nets along the banks of streams, in glens and ravines, on the seaside, on the lowest plains and prairies, and on the tops of the highest mountains, as far up at least as the timber line extends. I have

taken them on the highest railing of the dome of St. Peter's in Rome; have seen their round webs swinging against the cliffs of Mosquito Mountain Pass in Colorado, more than ten thousand feet high; have found them upon the mountains of Scotland; and captured the British Epeira umbratica from snares spun against the basaltic columns of Fingal's Cave.

Food Limits.

Their fixed positions are, of course, determined by their ability to obtain food therefrom; and, as their food is insects, the limit of insect life must also be the limit of spider life. For, although spiders are frequently at the mercy of the winds and are carried great distances when they are young, during the aeronautic stage, they cannot long sustain themselves and propagate their species if they chance to fall upon positions where it is difficult or impossible to obtain generous supplies of insect food.

Cocoon Secreting.

In seeking a spot upon which to place their cocoons, most Orbweavers go a little distance from their snares and construct the cocoon against the outer surface of a bush or tree, rock or wall, or cover it up within a leaf. As a rule, the disposition to find a secluded spot is quite manifest, but there are many exceptions. Other species deposit their cocoons within their webs, stringing them along one of the radii of the orb, as in the case of Uloborus, Epeira caudata, and Epeira bifurca; or suspend them within a maze of crossed lines which overhangs the orb, as in the case of the Labyrinth spider. Others, again, as with Argiopé, will frequently swing their cocoons within a specially prepared mass of crossed and netted lines, which are hung to branches or boughs, leaves, or blades of grass.

What is said of Orbweavers as to cocooning site is substantially true of the other Tribes, with, of course, such variations as are required by essential differences of habit and structure. For example, those Sedentary spiders, as the Lineweavers, which suspend their snares in positions quite like those of Orbweavers, also follow closely that Tribe in the general principle of selection for cocoon sites. In other words, they hang their cocoons in some part of their snare, or somewhere near, hidden beneath a convenient cover, or in a neighboring retreat.

So also many Tubeweavers, and the Tunnelweavers even more persistently, attach their cocoons to some part of their web, or weave one of their characteristic tubes around the egg case when it is once spun. In these cases the cocoon site is pretty sure to be identical with the dwelling place and snare.

Wanderers.

Among Wanderers the home site has less influence upon the cocoon site. As these animals pursue their prey over a more or less extended range of territory, the site of the cocoon is dependent on the place where the hour of maternity may overtake the females. Wherever they happen to be, the Saltigrades and Laterigrades will spin a tubular tent, enclose within it their cocoon, and there remain

until the young are hatched. However, it must be said that, with Saltigrades at least, there is a tendency before cocooning to prepare a permanent dwelling tent, to which, when the proper time approaches, the mother will resort to deposit her eggs. Lycosids also strongly incline to spin and burrow a cocooning house after their kind. But inasmuch as they deport their cocoons, they are apt to move about from site to site with their egg bags dangling at their tails, stalking prey and bivouacking in any convenient refuge.

II.

I infer that female spiders habitually prefer the night or early morning hours for cocooning. At least I have never been able to observe any species laying eggs, although I have frequently and quite persistently watched, both in artificial and natural sites, with a view to such observation. I am satisfied that it is within the power of the female to control the maternal function and compel Nature to await her pleasure for a considerable length of time. I cannot otherwise well account for some experiences with my captives. Moreover, I have spent many days during the last fourteen or fifteen years in wandering among haunts of spiders, north, south, east, and west, in our own country and Europe, but have never once surprised a female in the act of ovipositing. This leads me to the conclusion that spiders must commonly choose the night or early morning as the time for laying their eggs.

Night Cocooning.

FIG. 235. FIG. 236.

FIG. 235. Section views of abdomen, to show location of eggs. FIG. 236. Same, with eggs removed. (From alcoholic specimen.)

Others, however, have been more fortunate; and, judging from their accounts, and reasoning from the various stages at which I have partially observed the process, by putting the pieces of observation together, we obtain a tolerably accurate idea of the mother spider's mode of procedure.

Just before cocooning, the eggs will be found massed within the centre of the abdomen, the ovaries being so greatly distended as to compress and somewhat displace the surrounding and adjacent organs. (Figs. 235 and 236.) They are in this state gelatinous bodies, but have a spherical shape even in their soft condition. They are still jelly like objects when extruded from the ovaries along the vulval hook or ovipositor, and do not harden until shortly after they are laid.

When the mother is prepared to drop her eggs, and has satisfied herself as to locality, the next step is to prepare either a little sheet, or dish shaped dish, or a flossy tuft of spinningwork, against which the eggs are posited. I believe that this is most frequently done upwards in the case of females

who swing their cocoons free, as Argiope and Theridium; that is to say, the spider hangs with her back downward while ovipositing. But in many cases of females that have cocooned for me in boxes, the eggs must have been placed in the reverse position, since the cocoon was attached to the bottom of the box.

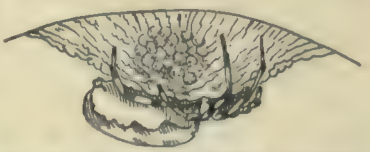


Fig. 237. Epeira strix placing eggs into a flossy boll of silk. (After Emerton.)

Of course, the species that fasten their cocoons to various surfaces, as do many Epeiras and most Tubeweavers, deposit the eggs downwards. Other fixed cocoons have as manifestly been placed upwards, as, for example, those spun on the under surface of stones, fallen logs, etc. Others, again, have been laid while the spider was in a vertical position, as when cocooning upon loose bark of trees and similar vertical sites. The bodily attitude appears to make little or no difference as to the facility with which the female can deposit her eggs. Whether directing them upward (with the dorsum towards the earth), or directing them downward (with the dorsum towards the sky), or depositing them against a vertical surface, with the head downward or upward, as the case may be, the mother is able to empty the ovaries with equal comfort and ease.

Ovipositing.

Mr. Emerton has observed several species in the act of ovipositing, and his brief notes upon the manner thereof are as follows:[1] Epeira strix first spins a rounded bunch of loose threads, into the middle of which she discharges her eggs, as shown in Fig. 237. The eggs, which are little drops of jelly, are held up by the loose threads until the spider has time to spin for them a covering of strong silk. It is to be regretted that the description here is so indefinite, as the term "covering of strong silk" may imply either the flossy boll which is invariably found to surround the egg mass of Epeira, or the smooth textured silken bag which immediately encloses the eggs and against which the flossy blanketing is laid. When a cocoon of Epeira strix and others of similar habit is cut open, this silken encasement is invariably seen, and it presents the appearance of having been the original substance against which the eggs were directly laid.

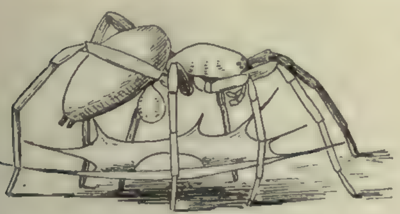


Fig. 238. Female Drassus in the act of dropping eggs. (After Emerton.)

The same author has been fortunate enough to observe the mode of positing eggs with two other tribes. The female Drassus (Fig. 238), spins a little web across her nest and drops the eggs upon it. They are soft, and mixed with liquid, and are discharged in one or two drops, like jelly. They quickly suck up the liquid, and become dry on the surface, sometimes adhering slowly

[1] Habits and Structure, page 101.

together. After the eggs are laid, the spider covers them with silk, drawing the threads over from one side to the other, fastening them to the edges of the web below. When the covering is complete, she bites off the threads that hold the cocoon to the nest, and finishes off the edges with her jaws.

Saltigrades.

Phidippus galathea (Attus mystaceus Hentz) spins, before laying her eggs, a thick nest of white silk, usually on the under side of a stone. In this she thickens a circular patch on the side next the stone, and discharges her eggs upward against it. (Fig. 239.) They adhere, and are subsequently covered with white silk, after the manner common to Saltigrades. Mr. Emerton had a female of this species that deposited her eggs in confinement; he records that, "instead of completing the cocoon properly, she ate the eggs immediately after laying them,"[1] a breach of maternal fidelity which I believe to be rare among araneads, even when cocooning in the unnatural conditions of a forced imprisonment.

Form of Egg Mass

The eggs are deposited in a mass, cylindrical, conical, or hemispherical, individuals of which are usually fastened together by a glutinous substance, but sometimes are deposited loose, so that they roll about in the hand when the cocoon envelope is cut. We are indebted to Menge for the following interesting observation: After all the eggs are deposited the spider rests for a season, when she commences to draw threads over the eggs, as if desirous of covering them up; but it soon becomes clear that something else is to follow. After a while she returns to the cocoon and discharges a clear liquid over the eggs, which is absorbed by them without in any way interfering with the web. This causes the eggs to swell to such an extent that they could no longer be contained within the animal. Menge thinks that this fluid proceeds from the semen pockets, which at this period are very much enlarged, and becomes mixed with the male semen, so that in reality the fructification of the eggs is completed by the female. The mother now appears very much exhausted. She lays down for a while on the eggs, and, finally, commences to spin them over, entirely covering them.[2]

FIG. 239. Phidippus galathea (Walck.) laying eggs within a silken cell. (After Emerton.)

Fructification.

Cteniza's Eggs.

Mr. Moggridge had the opportunity to observe the eggs laid by a specimen of our Cteniza californica, which was sent to him from America and kept for a while in captivity. The eggs were deposited in several clusters, at various times, upon the under surface of a gauze fastened upon the mouth of the box in which she was imprisoned. The first of these groups was laid during the night, between

[1] Structure and Habits, pages 99, 100.

[2] Menge, "Preussische Spinnen." The author adds "that it takes patience and perseverance to observe the spider during this entire process, and he had only succeeded twice."

FIG. 240. A, Cteniza californica; B, her trapdoor nest; C, group of eggs, natural size; D, same, magnified; E, a second group, magnified; F, the same, largely magnified. (After Moggridge,)

the 12th and 13th of July, in a cluster shaped like a raspberry. The eggs were grayish white or pale brown, and varied in shape from globose to oblong. All were very small, the largest one half a line in its greatest length.

A fortnight later, July 27th, another cluster of eggs was laid, this time between the hours of 5 and 8 P. M. When the lamp was brought in at the latter hour, Mr. Moggridge perceived what he took to be a drop of water hanging from the gauze covering, above and rather in front of the spider's door, the position occupied by the clusters of eggs previously described. On closer inspection this proved to be a drop of pellucid, colorless liquid, in which some thirty eggs floated. One egg was laid on the gauze at some distance from the main group, and several were also attached to the inside of the tin box. At midnight he found that the drop had coagulated and contracted, and by the following morning the mass was quite dry and resembled the former group, only that it was not quite so convex. Some of the eggs forming these clusters were much larger than in the preceding one, and one measured as much as a line in length by half a line in breadth.

Between the above date and the end of November, when the spider died, eggs were laid on seven distinct occasions, namely, on July 31st, August 11th, 15th, and 31st (when he found the eggs floating on a drop of liquid, having been deposited on the gauze between two and half-past four in the afternoon), September 9th (twenty-three eggs laid on the earth near the entrance to the nest), September 19th (about thirty eggs on the gauze), November 4th (about thirty eggs on the gauze). Thus, between July 13th and November 4th, this spider laid nine clusters of eggs, all but one of which were placed on the same part of the gauze cover, above and a little in front of the door, and the total number of eggs deposited cannot have been less than two hundred and fifty.[1]

Of course, it is difficult to account for the peculiarities of this female in oviposition, for there is little doubt that this manner of laying eggs in disconnected groups, at extended intervals of time, is quite foreign to the usual habit of the species. During the long journey from her native home she may have experienced a shock resulting in a morbid condition of the ovaries. Undoubtedly, like her congeners, of whom Mr. Eugene Simon gives an account (see Chapter V.), Cteniza californica lays her eggs in one mass, and suspends them within her burrow. But the above facts at least show the power of the female to control the function of ovipositing, and indicate that there are certain irregularities in that function, more or less under the control of the female, which may give a clue to the habitual production by certain species of several cocoons, and the occasional multiplication of cocoons by other species.

[1] Moggridge, "Trapdoor Spiders," Supplement, page 203 sq.

III.

When the eggs are laid the spider mother proceeds to spin the outer envelope by which they are protected, and within which the progeny, when hatched, may find a comfortable home until sufficiently matured to begin life for themselves. This external structure differs, among various species, in shape, size, interior arrangement, and more or less in the character of construction. The details of these points have appeared in the preceding chapters, and they form some of the most interesting features in the life habits of araneads. The cocoon may be described in general terms as consisting of a silken sheet or sac surrounding the eggs, a padding of greater or less compactness above that, and a case of a more or less compact texture surrounding the whole.

Shape of Cocoon.

The shape of the cocoon appears to have no special relation to the maternal instinct, but is probably regulated by the habits of the particular species and the character of the cocoon site chosen. It has already been seen that the forms, although at first view they seem to be quite varied, may, by analysis, be reduced to the round or hemispherical. In other words, the eggs, as they drop from the spider's ovaries, naturally assume a more or less rounded form when the cocoon swings free; and when extruded against a fixed surface as naturally form into a hemispherical mass. This is simply the result of the law of equilibrium. As the maternal care is directed solely to covering up and protecting the eggs, the shape of the egg mass inevitably regulates the shape of the spinningwork woven around it. It thus would seem that the maternal purpose is shown in the fact of enclosing the eggs within the cocoon, and not in the external shape which that cocoon assumes.

Materni-ty and Structure

However, a measure of maternal interest and intelligence is undoubtedly found in the architectural details of the cocoon. I have shown (Chapters IV. and V.) that these have a tolerably wide range; that some cocoons are extremely simple in their structure, and others quite complex. To what degree are these differences regulated by maternal affection and intelligence? This question cannot be considered wholly from the standpoint of the cocoon structure itself, for other elements enter into consideration, as the natural environment chosen for a cocoon site, or the artificial environment prepared for it. That is to say, a cocoon may be quite simple in its structure, having little spinningwork to directly enclose the egg mass, but, as in the case of Dolomedes, have a supplementary protection of a leafy tent, and an associated enclosure of intersecting lines, which add materially to the protection of the eggs. Of course, in thinking upon the degree of intelligence and affection exhibited by such a mother, the external protection must be an important factor.

What is the relation between the simplicity or complexity of a cocoon's

construction, and the amount of care which the mother gives it? There is much difference in the extent of elaboration of cocoons. The simplest construction of which I have any knowledge is that of our common cellar spider, Pholcus phalangioïdes, which surrounds its little cluster of agglutinated eggs with the barest filament of silk through which the eggs are entirely visible. This rude cocoon the mother holds underneath her jaws, and there carries it until the spiderlings are ready to hatch out, when they take their place upon the straggling lines at the top of the maternal snare. Steatoda borealis spins a cocoon scarcely more elaborate than the above; she hangs it within her snare of crossed lines and stays near it. The cocoons of Lycosa and Dolomedes are also carried about by the mothers until they are hatched or nearly ready to hatch. These cocoons are rather simple in structure, consisting of a patch of spinningwork rolled up into a ball, without any internal padding or protection whatever. The cocoons of many Tubeweavers, the Drassids, for example, and the cocoons of Laterigrade spiders are simple parchment like textures, spun against a surface, and are also free from any internal padding or external protection.

Complexity and Maternal Care.

These spiders are in the habit of watching their cocoons, remaining near them until the little ones are hatched. Thus far it might be said that there is some reason for the conclusion that lack of complexity in the structure of a cocoon is supplemented by additional vigilance on the part of the mother in watching the cocoon.

Among Orbweavers.

Let us see how it is among Orbweavers. The most complex cocoons are found among these spiders. That of Argiope, for example, exhibits remarkable regard for the protection of eggs and young, by its tough external case, its thick lined padding of brown silk, which nearly surrounds the egg mass, and the sac which contains it. Argiope, as far as known, never watches her cocoon.

The same is true of most species of the genus Epeïra, whose cocoons are frequently enclosed within a tent of sheeted spinningwork or of closely laid lines, and are themselves composed of several layers of spinningwork of various textures. Most spiders of this genus give their cocoons no care after they have made them. There are, however, exceptions. Epeira cinerea, for example, not only encloses her eggs in a well furnished cocoon, but adds to it scrapings from the bark of trees or the dry wood surface upon which the cocoon may be fastened. Yet, according to Mrs. Mary Treat, this spider is extremely watchful of its cocoon.

Cocoon Vigils.

Cyclosa caudata provides the ordinary enswathment for her eggs, and adds to that an exterior armor of the disjecta membra of insects captured by her. Yet these cocoons are hung within her snare, and during the cocooning season she is found constantly clinging to the end of her cocoon string. However, that this contiguity is an actual vigil is not proved.

The Speckled Agalena makes a cocoon which equals in its complexity the most carefully prepared of the Orbweavers. It not only surrounds its eggs with several swathings of silken material, but adds a mattress of sawdust or bark chippings scraped from surrounding objects. Yet, according to Mrs. Treat, a spider mother of this species kept watch over her cocoon long after the frosts of winter had fallen, it being preserved in a sufficiently protected spot.[1] Mr. Emerton attributes to this spider the habit of remaining near her cocoon until she dies.[2] Nevertheless, my own numerous observations compel me to believe that this species gives an example of complexity associated with isolation of cocoon.

The interesting California spider, Segestria canities, spins a string of ten or a dozen cocoons, which it suspends in the midst of a thick maze of crossed lines, forming a strong protection, yet she keeps her home in a silken tube spun along one side of the cocoon string.

Tegenaria agrestis of Europe makes a well protected and cushioned cocoon for her young, yet she watches it carefully. The cocoons of all known Saltigrades are all protected underneath a thick exterior tent and by a stout case, but the mothers remain near, within the cell, although, according to Professor Peckham,[3] underneath an extra covering. Such examples as Segestria and the Saltigrades cannot positively be cited as cases of cocoon vigil, but at all events the mother's domicile includes the cocoon within its premises.

The Inference.

The above facts appear to indicate, first, that cocoons which are least carefully protected by spinning industry have a supplementary defense in the personal care of the mother; on the other hand, second, that cocoons which are abandoned as soon as made, and are entirely without maternal sentry, are protected by elaborate structures; but, third, in some cases the complex structure and the maternal vigil exist together.

IV.

Multifold Cocooning.

Orbweavers differ among themselves as to the number of cocoons spun by females. Certain species, as the Tailed and Labyrinth spiders, habitually spin several cocoons; others, again, as most Epeiras, ordinarily spin but one. This habit must be subject to some variations, the reasons for which are not clear. Epeira apoclisa, according to Lister, lays three and even four cocoons in the period of a little more than two months. Termeyer makes the statement that Epeira diademata, when well fed, will make six cocoons.

Several years ago a ministerial acquaintance, Rev. P. L. Jones, brought me two cocoons of the Basket Argiope, both of which, he affirmed, had

[1] "My Garden Pets," page 18. [2] New England Drassidæ, page 200, (36).
[3] Letter to the author.

been made by a single mother. It struck him as a strange circumstance, and he reported the fact to me. Only recently Mrs. Mary Treat has published a description of what she considers a variety of this spider, Argiope multiconcha,[1] which habitually makes as many as four and sometimes five cocoons. I have one of these strings, which was made in a kitchen where a great cooking stove was in almost constant use to supply the demands of a large family. It contains four cocoons, which were hung close to each other, and precisely in the manner of those of Basket Argiope, which they exactly resemble. The habitat of this spider, as far as now known, is Missouri. The animal itself differs very little from Cophinaria. Unfortunately, the one specimen that I have seen was so much dried up that it could not be figured, nor could any distinctive features be readily traced; but it seems to differ in no essential respect from Cophinaria. Thus, the interesting question emerges, what are the conditions controlling this function in this spider? It can hardly be quantity of food, as with Termeyer's Diademata. If it be quality, upon what meat does this aranead feed, that she should so excel her congeners in cocooning industry? A tropical spider, Argiope aurelia, it may here be stated, according to Mr. Pollock, makes ten cocoons.

Argiope multiconcha.

V.

The number of eggs within cocoons differs very much in different species, and even among different individuals of the same species. Walckenaer reports[2] that Epeira diademata has been found by him to contain from three to four hundred eggs, and again from six to eight hundred, a wide range of difference certainly. I have counted as many as eleven hundred and ten young spiders in the cocoon of one Argiope cophinaria, and eleven hundred and fifty-two spiderlings in another; and this is probably near the normal number. Some females lay many less; as low, at least, as one hundred and fifty. The Peckhams give the number of eggs laid by this species as varying from five hundred to twenty-two hundred. According to Staveley, the cocoons of Argyroneta aquatica range from forty to one hundred in number.

Number of Eggs.

The reasons for this varying fertility are not certainly known. They depend, no doubt, upon the female's vital condition. A full measure of health and abundant nutrition doubtless conduce to the normal number of eggs, and this is probably diminished by physical weakness and lack of nourishment. I believe also that the conditions surrounding the spider influence the number of eggs, for females in artificial confinement seem to deposit fewer than those in natural habitat.

Spiders that make a number of cocoons, as a rule deposit few eggs in every one, so that the aggregate of eggs laid is about equal to the number

[1] See "American Naturalist," December, 1887, page 1122. [2] Aptères, Vol. I., page 154.

in the single cocoon of other species. The Labyrinth spider lays from sixty to eighty eggs. The Tailed spider about the same. The Bifid spider an aggregate of one hundred to one hundred and fifty in all her cocoons. There is a marked difference in the number of eggs contained in the several cocoons in one brood or cocoon string, as though the female issued an unequal number of eggs at the various periods of ovipositing.

In tribes other than Orbweavers, the various species show the same differences in the number of eggs contained within their cocoons; for example, Tegenaria medicinalis has about sixty eggs; Agalena nævia, a hundred or more; Dysdera bicolor, twenty to thirty. Walckenaer reports Agalena labyrinthea to contain sixty eggs; Tegenaria domestica from sixty to one hundred and eighty; Dolomedes mirabilis, one hundred to one hundred and sixty; Lycosa narbonensis, five to six hundred; Lycosa agrestis, one hundred and eighty. Dysdera hombergii (Staveley) lays from twenty to thirty eggs.

Size of Mother.

It perhaps may be said, as a general rule, that the number of eggs deposited by any species corresponds with the size thereof. Thus we have seen that our large Argiope will lay as many as twenty-two hundred eggs. Westring counted eight hundred eggs in a cocoon of Epeira quadrata;[1] Epeira diademata will lay as high as eight hundred eggs. Both of these are large species. The great tarantula, Mygale blondii, deposits as many as three thousand eggs. On the contrary, we find such a diminutive Saltigrade species as Synagales picata laying but three eggs, while Phidippus morsitans, one of the largest of the Saltigrades, lays one hundred and eighty eggs, thus being one of the most fertile species.[2] The Lineweaver Theridium variegatum has six eggs in her cocoon. Oonops pulcher makes several cocoons, and deposits two eggs in each one.[3] The cave spider Anthrobia mammouthia lays from two to five eggs, while another cave species, Nesticus pallidus, deposits from thirty to forty.[4] It will thus be found, I think, that small and feebly organized species tend to deposit a smaller number of eggs, although there are some marked exceptions to this.

Fertility and Exposure.

The Peckhams give some interesting suggestions as to the relations between fertility and exposure to peril. For example, the fact is pointed out that while Argiope cophinaria is sufficiently well protected, her cocoons are exposed to serious loss through the assaults of ichneumon flies, and, perhaps, also through exposure to the weather. Professor Wilder suggests that the immense fertility of Nephila plumipes is counterbalanced by the destruction of its cocoons, which are so placed, depending from leaves, that great numbers of them are washed away and destroyed by rains.

The little Attid spider Synagales picata lays three eggs. Yet, beyond

[1] Araneæ Sveciæ, page 31. [2] The Peckhams. [3] Staveley. [4] Packard.

the fact that it is small and dark colored, this species has absolutely nothing to protect it but the resemblance which it bears to an ant. Can this alone give the species so great advantage that it is able to maintain itself with as low a birth rate as three or four in a season? Considering the direct relation between mortality and multiplication, it is plain that no species could maintain itself at a low birth rate were not its mortality correspondingly low. It must then either practically have no enemies, or its means of protection from enemies must be uncommonly efficacious.[1]

Mimicry and Fertility.

I state this theory without giving assent to it, and add the simple remark that this species, or an Eastern species which greatly resembles it in mimicry of ant forms, makes a cocoon of precisely the same character and protected in the same way as that of Phidippus morsitans, one of the most fertile species among the Attidæ. Undoubtedly, cocoons of one species are exposed to the same dangers as those of the other. Whatever advantage, therefore, Synagales possesses in the way of protection is limited to the mature form, and does not accrue to the eggs.

VI.

Maternal Vigils.

We come now to speak of the character of maternal solicitude as shown by female spiders in the vigil of their cocoons. It is beyond doubt that many species do guard their egg sacs with more or less constancy during the period of hatching. The term "brooding" has been applied to this action, but, of course, is inexact, and only implies that the mother remains near or sometimes roosts upon the cocoon, and, it is inferred, exercises some sort of protection against the numerous enemies which assail the eggs.

Mrs. Treat[2] has observed that Epeira cinerea broods her cocoons for a couple of weeks, and then drops dead from her maternal watch. Certainly she has good occasion for thus mounting guard, for of several cocoons received from that lady, every one was infested by parasitic ichneumons, whose white pupa cases occupied portions of the egg padding. I have never observed an orbweaving spider in what I could consider an actual state of brooding her egg nest, although I have sometimes seen female Orbweavers clinging to cocoons apparently lately made. This position seems to me to be rather due to indisposition to leave the vicinity after the exhausting task of spinning and enswathing her eggs. But various observers attribute the habit of brooding to some of the Epeiroids of England. So, also, Menge, speaking of the egg nest of Epeira diademata, says that the spider literally guards it with her life. It is spun under a horizontal stem beneath the bark of trees, or under

[1] "Observations on Sexual Selection," page 74, sq.

[2] Communication to the author.

fallen leaves, which are attached to the ground and covered with strong threads. The mother lies down upon her cocoon, never leaving it to take nourishment, thus starving herself to death in two or three weeks.[1] This author makes a like statement concerning Singa albovitata. The phrase "starving herself to death" must, however, be taken in a figurative sense, for the fact is not one of maternal sacrifice, but the inevitable debt of Nature after the maternal functions are fulfilled.

Epeira diademata.

Notwithstanding the above statements, I must say that I have met with no evidence that any mother spider, during so called brooding, ever actively exercised herself to protect her eggs against assault of hymenopterous or other natural enemies. I once watched a female Herpyllus ecclesiasticus during more than two weeks' vigil of her cocoon. She never appeared to leave the vicinity of her button like egg nest, which lay near a crevice into which she frequently retired, and indeed was apt to retire at the sign of any disturbance made by myself. Sometimes she had her station upon the cocoon, embracing it with her legs, but during all this period I failed to see the approach of any natural enemies, and therefore was not able to record the fact that this vigil resulted in any practical benefit to her embryo progeny.

Parson Spider.

With few exceptions, of which some have been noted, and which seem to me to have doubtful features, Orbweavers hold no vigil over their cocoons. As a rule the whole wealth of maternal care is expended upon the elaboration of the egg covering, after which, in most species, cocoon and eggs are abandoned to the foster love of Nature while the mother goes away about her business of food gathering or falls upon death. It may be thought that those species which make several cocoons present an evident exception, as in the cases of Epeira basilica, caudata, bifurca, and labyrinthea, whose cocoons are hung within their snares. But I have not been able to obtain any evidence that the cocoons of these species receive special maternal care in the way of personally protecting them from enemies, or aiding the young within them to make their egress, or looking after the brood when escaped from the cocoon.

Orbweaver Vigils.

Caudata may, indeed, often be seen hanging to the lowest cocoon of her series, suspended along the vertical axis of her orb; but that is the natural position for the spider under ordinary circumstances, and it may have been assumed simply for convenience. I have never seen the slightest indication of a desire on the part of the little mother to mount from the lowest to the higher and highest ones of the string with a view to protect them or oversee them.

Caudata.

In the case of Labyrinthea I have little doubt in saying that she

[1] "Preussische Spinnen," sub Epeira diademata.

exercises no care at all upon her cocoon string. This is ordinarily stretched, as may be seen by consulting Chapter IV., page 100, at a position somewhat removed from her ordinary nesting site. It is true, her silken tent is sometimes spun just beneath the lowest of the several cocoons which she strings in a line one above another. But even in this case I have no evidence that she exercises a personal vigilance upon them, or protects them in any way.

Uloborus!

The known species of Uloborus also suspend their several cocoons along one of the radii of their horizontal orbs. Hentz, indeed, says that Uloborus mammeata[1] watches her cocoon with incredible perseverance, and shows great courage in attempting to defend it against human disturbances. Fear seems to be wholly merged in maternal solicitude, and as soon as the cocoon is torn from its place, the mother, having remained firmly attached to it, proceeds to secure it with new threads. I have observed similar behavior on the part of Theridioid spiders, who hang their cocoons within the limits of their snare, and may sometimes be seen embracing them or stationed near them.

Protective Purpose.

Even this account may fail to assure one that the mother would have repelled the attacks of natural enemies, and that she benefited her offspring by her stubborn keeping to her post. Nevertheless, it seems to me a legitimate inference that the exercise of such maternal patience in vigil, and energy and courage in resisting attempts to rob her of her treasure, indicate a purpose to protect the cocoon from natural enemies. Why does the mother so persistently maintain her position close by her cocoon? Why is she ready to undertake even such a hopeless venture as maintaining her egg sac against the tremendous odds of a raiding naturalist? These questions appear to me to have but one answer. Motherhood is on guard beside the cradle of her young, moved by a natural impulse to protect them from the possibilities of natural peril. Even though no one has yet seen or recorded the actual defense of the vigilant mother against such enemies as ichneumon flies, egg loving spiders, etc., the circumstantial evidence seems to be good that such defense must often occur.

Other Tribes.

It is known that outside of the Orbweavers some species of spiders do persistently brood their egg nest, or rather keep a close watch upon them until they are hatched. I have already intimated that I have seen this quite in detail with Hentz's Herpyllus ecclesiasticus, and I have observed the same fact with Dolomedes tenebrosus. Mrs. Treat notes the habit of a Thomisoid mother, probably Misumena vatia, to remain near her cocoon, watching it with untiring patience until the young are hatched. Hentz also speaks of this species[2] as watching its cocoon until the eggs are hatched.

---

[1] Spiders of United States, page 129. [2] Thomisus fartus, "Spiders U. S.," page 78.

PLATE III.

[illegible] VATIA. 3, A LATERIGRADE [illegible] 5, EPEIRA PARVULA ON [illegible] PECKHAMS. 6, TETRAGNATHA [illegible] 7. PURSE [illegible] TUBE.

[illegible] This is ordinarily stretched, as may be seen by [illegible] page 100, at a position somewhat removed from her [illegible] site. It is true, her silken tent is sometimes spun [illegible] of the several cocoons which she strings [illegible]. But even in this case I have no evidence that [illegible] vigilance upon them, or protects them in any [illegible]

[illegible] also suspend their several cocoons along [illegible] horizontal orbs. Hentz, indeed, says that [illegible] watches her cocoon with incredible perse- [illegible] great courage in attempting to defend it [illegible] Fear seems to be wholly merged in maternal [illegible] cocoon is torn from its place, the mother, [illegible] to it, proceeds to secure it with new [illegible] similar behavior on the part of Theridioid [illegible] within the limits of their snare, and may [illegible] them or stationed near them.

[illegible] the mother would have [illegible] natural enemies, and that she benefited her off- [illegible] stubborn keeping to her post. Nevertheless, it [illegible] that the exercise of such [illegible] patience in vigil, and energy and courage in resisting [illegible] rob her of her treasure, indicate a purpose to pro- [illegible] natural enemies. Why does the mother so per- [illegible] position close by her cocoon? Why is she ready [illegible] such a hopeless venture as maintaining her egg sac [illegible] odds of a raiding naturalist? These questions [illegible] have but one answer. Motherhood is on guard beside [illegible] young, moved by a natural impulse to protect them [illegible] of natural peril. Even though no one has yet seen [illegible] actual defense of the vigilant mother against such enemies [illegible] egg loving spiders, etc., the circumstantial evidence [illegible]

[illegible] outside of the Orbweavers some species of [illegible] their egg nest, or rather [illegible] I have already intimated that I [illegible] Herpyllus ecclesias- [illegible] Dolomedes tene- [illegible] notes the habit of a Thomisoid mother, probably [illegible] to remain near her cocoon, watching it with [illegible] Hentz also speaks of this species [illegible]

[illegible] (Thomisus [illegible] "Spiders U. S.," page [illegible]

PLATE III.

MIMICRY OF ENVIRONMENT.

1, 2, MISUMENA VATIA. 3, A LATERIGRADE ON BARK. 4, EPEIRA STRIX. 5, EPEIRA PARVULA ON LICHEN, AFTER PECKHAMS. 6, TETRAGNATHA EXTENSA AND THE ORCHARD SPIDER. 7. PURSE-WEB SPIDER'S TUBE.

Theridium studiosum, when its web is destroyed, does not abandon the cocoon, which is orbicular and whitish and is placed in the central part of the web. The mother then grasps it with her mandibles and defends her progeny while life endures. Her maternal solicitude is not limited to her cocoon, but she also takes care of her young, making a tent for their shelter and remaining near them until they can protect themselves.[1]

Mother Turret Spider.

Toward the last of July the female Turret spider appears at the top of her tower with a cocoon of eggs, about as large as a hazel nut, attached to the spinnerets. She exercises the greatest care over her cocoon. On cool days she keeps it out of sight down in her tube, which is about eight inches in depth, including the tower. But when Mrs. Treat set the jar in the centre the mother spider soon came up and put the cocoon in the sunshine. When the weather was cool enough for fire in the room, if the jar were placed near the fire the spider placed her eggs on the side next the stove. If the jar were then turned around, the mother presently moved the cocoon around to the warm side, letting it hang outside of the walls of her tower. On the 6th of October the young spiders were hatched, and at once perched upon the mother's back, and even on her head and legs. She carried her cocoon two months before the eggs hatched.

Lycosids.

The Lycosid Oxyopes viridans makes a conical cocoon having small eminences, to which are attached the threads that hold it suspended firmly in the air. After it is finished the mother watches it constantly, never leaving its unprotected family.[2] Professor Hentz, speaking of the general maternal instincts of the Lycosids, says that the mother defends her progeny to the last, and her feet can be torn from her one by one before she can be compelled to abandon her treasure. Thus can maternal tenderness be exhibited in beings which are relentless to their own species, and even to the sex which gives life to its progeny.[3] I must say that my own experience gives no such examples of persistent devotion under attempts to separate Lycosids from their cocoons. If the female of Lycosa lenta be caught or wounded, the little ones escape rapidly in all directions, but the mother is faithful to her duties and defends her progeny while life endures.[4]

Dolomedes.

A female of Dolomedes albineus was captured by a child, who transfixed her cephalothorax with a pin. The creature was placed in a glass jar, and the wound, instead of proving mortal, healed rapidly. After remaining inactive about three days, the spider made an orbicular cocoon of light brown color, in which her eggs were placed. She held it constantly grasped in her mandibles, and seemed intent on watching it to the last; but the effort of cocooning once made,

[1] Hentz, id., page 106. [2] Id., page 48. [3] Id., page 25. [4] Id., page 28.

her strength failed. The wound opened again, and, the fluids running freely, she gradually lost her muscular power. But faithful to her duties, the last thing which she held was the ball containing her future family. Can maternal tenderness be more strikingly exhibited?[1]

Dr. T. W. Harris, whose work on "Injurious Insects" is well known, found in Massachusetts a female Dolomedes lanciolatus on a large, irregular, loose horizontal web, at one extremity of which was situated her egg bag with her young, which the parent appeared to be watching.[2] Micromata marmorata remains constantly by its round white cocoon, which it embraces closely with its long legs, while it hangs suspended by one thread in the middle of its snow white tent.

Many British spiders have the same habit of caring for their cocoons.[3] The female of Philodromus cæspiticolis conceals herself with usually two flattened white cocoons in the large nest, which she forms upon the end branch of some shrub, drawing the leaves into a convenient position with silken threads, which form a close tissue of a somewhat gray color. The cocoons are frequently of unequal size, the largest being about one-fourth inch in diameter. If the cocoon be touched the mother will not take flight, but will defend it with all her power.[4]

British Examples

Drassus ater makes a plano convex cocoon, which is attached by its flat side to a stone or other substance, on which the cell is formed. This cocoon is white or slightly yellowish at first, and afterwards becomes reddish in color. The female remains on guard by her eggs.[5] The female of Drassus lapidicolens conceals herself in a cell formed between the surface of the earth and the under side of a stone, near which she spins some threads, forming an irregular snare. In this cell, in the month of July or August, she places her cocoon, covering it with dead leaves. This cocoon is at first in the form of a flattened sphere, but becomes nearly round when the young are about to escape. It is white, and about half an inch in diameter. The mother remains with her young for some time after the eggs are hatched.[6]

Clubiona.

Clubiona holosericea makes a white flattish cocoon one-fourth inch in diameter in June, and places it in a long tube shaped cell, formed on the under side of a leaf, or in some crevice, as of the bark of a tree. The female remains in this cell except when she leaves it to pounce upon an insect passing near its opening, and which she carries into the cell. The cell is divided into two chambers, in which, in the month of June, male and female may be found each occupying one. The spider is timid until she becomes a mother, when she will face any danger rather than abandon her cocoon. Before that time, if driven from her

[1] Hentz, page 39. [2] Id., page 41. [3] Staveley, British Spiders, page 168.
[4] Id., page 85. [5] Id., page 91. [6] Id., page 97.

cell, she falls to the earth without drawing a line with which to suspend herself, feigns death for some time, and then, making a rapid flight, sets to work to build a new house in a fresh place.[1]

VII.

Special Cases of Mother Care.

Mrs. Mary Treat, in a little work designed for popular use entirely, gives several extraordinary examples of maternal care on the part of spiders. One of these was a female of Dolomedes scriptus, which first attracted attention by the fact that she was carrying a bag of eggs about the size of a small cherry, with which she planted herself on top of a leaf nest of a Shamrock spider (Epeira trifolium). One morning Dolomede was missed from her accustomed place, but upon searching some adjoining ferns the characteristic cocoon tent of the species was discovered. It was three or four inches in length and from two to three in breadth, composed of ferns bent over and fastened together. Through one of the openings between the leaves the cocoon was seen suspended from the ceiling, precisely as I have myself observed it, and as is represented in the sketch Fig. 177, Chapter V.

In two or three days thereafter the young Dolomedes were hatched and swarming all over the outside of the cocoon. When the leafy domicile which enclosed them was touched the little ones ran down the lines in the direction of Mrs. Treat's finger, as if they expected something, and reminded the observer of young birds, which always open their mouths to be fed whenever they are approached by a human being, not having yet learned to recognize their parents.

Feeding the Young.

This behavior led Mrs. Treat to suspect that the youngling spiders were fed by their mother, and she accordingly kept watch upon the colony. One evening, not long afterwards, the mother Dolomede was seen with a large fly in her mandibles taking long strides in the direction of her domicile. She was soon inside, and the little ones thronged around her and sucked the juices of the fly while she held it. The fly had previously been crushed in the mother's jaws as though to make the food available for her nestlings. How long this process continued is not stated. It is a great pity that the details were not given, and the lack of these details leaves in my mind the question, was this really a case of feeding the young? Or did the Dolomede simply return to her nest to prey upon the food which she had gathered for herself, and permit, without interference, her brood to share in the repast? I have seen a mature Argiope (see Vol. I., page 256) feeding upon a blue bottle fly, while a number of small Diptera were sharing in the feast, having crowded up to the very jaws of the spider to sip the juices of the carcass. Of course, no purpose to feed the little flies could be inferred on

[1] Staveley, page 100.

the part of the big spider. Might not a deliberate intention to feed her young be excluded from the act of this mother Dolomede on precisely the same ground?

Quite as extraordinary as the above is the behavior of a little Jumping spider, Attus nubillus, related by the same observer.[1] This spider deposited her cocoon, after the manner of her genus, within a couple of curled leaves of prickly Smilax rotundifolia. Mrs. Treat opened the nest and found that the spiders were apparently just hatched, and were of a pale green color. The mother was not then in sight, but knowing that Attus remains with and cares for her young until they leave the nest, the observer waited and was rewarded by witnessing the little mother's return. For a time she seemed to look with dismay upon her pretty home torn asunder, and her spiderlings scattered around, but soon proceeded to gather the younglings together and tuck them back under the silken canopy. One spiderling, which had wandered farther than the rest to the verge of the leaf, was picked up bodily, as a cat would carry its kitten, and put back into the flossy interior of the cocoon. Then the mother set about repairing her damaged cocoon; and after the rent was mended the young were not visible. She also tried to bring the enclosing leaves together again, but presently abandoned that effort.

Personal Care of Young.

She remained on the outside of the nest, and no threatened danger would induce her to leave. She sprang towards the observer's hand, and fiercely grasped the point of a pencil thrust near her. Several times daily the nest was visited, and the mother was found persistently present until the third day, when she was missed. A second time the cocoon was opened, and the spiderlings found to have made the first moult, and were crawling about slowly. When the mother came back and perceived her young disturbed again, she varied her behavior so far as to look around for the cause of the disaster—spying around leaves, and over and under them. Finding nothing, she soon became quiet, put her brood within the cocoon once more, and again repaired the damage. This completed, she went to work to bring the leaves together. The tips now stood two inches apart, while at the base or stem end the space was half an inch. The leaves were thick and leathery, and the petioles stiff and firm. She fastened a thread of silk to one leaf and then to the other, and went back and forth strengthening and shortening the lines, and slowly bringing the leaves together. The next morning they were found quite joined, and the interior entirely hidden.

Repairing the Nest.

A third time, during the mother's absence, the leaves were separated without disturbing the young within their cocoon. When the mother returned she did not attempt to reconnect the leaves. In a day or two

[1] "My Garden Pets," pages 64–68.

thereafter a door was seen in one side of the nest, out of which the spiderlings soon made their exit. They were quite lively; several were on a leaf; they seemed to be playing, springing at each other, then back into the nest and out again. When the leaf was touched every one instantly disappeared.

Spiderlings.

At the next visit Mrs. Treat moved her pencil over the nest a little harshly. Instantly the spiderlings all fled from the abode, springing in every direction; but, before leaving, every one must have fixed a thread to the leaf, for all soon returned, slowly ascending, taking in their tiny cables, until they reached the leaf, when they cautiously approached the nest. "I was somewhat puzzled at their return, after such a flight," says the writer, "until I saw the mother with a fly and the little ones all around her sucking its juices. This, then, was the reason of their remaining together—they were fed by her."

This account is so fully detailed, and contains the evidence of such repeated and careful observation, that we have no room to doubt the fact that the mother Nubillus maintains a remarkable degree of oversight and care in behalf of her young during the period of their early life and growth. The manner in which the spiderlings were covered again and again within the silken egg sac, especially the extraordinary fact of one being carried in the mouth and placed along with its comrades, suggests to us a degree of maternal solicitude on the part of this aranead which falls little short of that exhibited by the mothers of vertebrate animals. If we add to this the fact, of which Mrs. Treat appears to have no doubt, that the mother actually brought food to the nest and bestowed it upon her offspring, we shall be compelled to place the mother aranead even yet nearer to her vertebrate sisters in the quality of her maternal affection and care. It is greatly to be regretted, however, that in this case, as well as that of Dolomedes scriptus, only one example of so called feeding could be observed and recorded.

These detailed observations confirm the statements of Blackwall, that "the young of some species live together for a considerable time, and in many instances are supplied with sustenance by the mother;" [1] and again, that the young of Theridium riparium "remain with the mother for a long period after quitting the cocoons, and are provided by her with food, which consists chiefly of ants." [2] I have observed the young of spiders, particularly of a small species of Dictyna,[3] feeding upon parts of a dead fly which the mother was eating. At least the young seemed to be feeding, and I have the belief that they were doing so, although I could not positively declare it, since they may have simply been resting upon the limbs and other parts of the dead insect, after the manner of young

[1] Spiders Gt. B. & I., Intro., page 7.

[2] Id., page 9, and Researches in Zoology, page 356.

[3] Dictyna philoteichus, Vol. I., page 354.

spiders to get themselves upon all objects and in all manner of positions within their neighborhood. Certainly these observations must open up before our minds more clearly than ever the existence of a high degree of maternal instinct in spiders, and the possibility of discovering yet higher.

VIII.

Among experiments on the mental powers of spiders, made by Professor and Mrs. Peckham, were some on the strength of the maternal feeling.[1] They proceeded by removing their cocoons from the mothers and then noting with what degree of eagerness they sought to regain them; and also by determining for how long a time they would remember the cocoons after they were separated from them. The Lycosids were selected as the principal objects of study, because these spiders keep the egg sac attached to the spinnerets until the young are hatched, and thereafter carry the spiderlings on their backs for a certain length of time, until they are able to shift for themselves. It was thought that the lengthening of the period of infancy during which the female cares for her young, might, in the case of araneads, as in that of more highly organized animals, have produced a greater development of maternal instinct than in other species of spiders where the eggs receive little or no attention from the spider after she has deposited them. The following will show the character of some of the experiments:—

Strength of Maternal Feelings.

The cocoon of a female Pirata piraticus was removed from her. During this act the mother seized the egg sac with her falces several times and tried to escape. After the removal she seemed much affected and searched about in all directions to find her lost treasure. In an hour and a half the cocoon was restored to the mother, who immediately took it between her falces and passed it back to its proper place beneath the abdomen. It was again removed and returned in three hours. The mother did not seem as ready to receive it as in the first instance, but after a little hesitation took it up and carried it off. From three spiders of the same species cocoons were removed, and retained for the space of thirteen, fourteen and a half, and sixteen hours respectively. All remembered them and took charge of them when they were returned. The same cocoons were again removed and retained for twenty-four hours, when they were restored. Two of the mothers refused to resume their maternal duties, seeming not to recognize their cocoons. The third, however, after her cocoon had been placed in front of her seven times, slowly resumed charge of it, but with none of the eagerness before displayed.

Lycosids.

Absence Weakens Interest.

Experiments with a female Lycosa of an unknown species resulted as follows: After being separated from her cocoon for a whole day the mother

[1] Mental Powers of Spiders, page 397.

recollected it, and promptly took it up. A second individual, after an absence of forty-three hours, had apparently forgotten all about her cocoon, since, although she touched it five times with her legs, and it was four times placed directly under her, not until the fifth time did its presence recall her to a sense of duty. She then very slowly and languidly took it up and passed it to the usual place. From another individual the cocoon was kept forty-eight hours, but the little spider could not remember so long, and, although the observers worked long and patiently to make her recollect, she would have nothing more to do with it. Notwithstanding many efforts, no female among the Lycosids was found constant in her affection to her cocoon after as long a period as forty-eight hours.

Two Days Limit.

Several species of the Attidæ and Thomisidæ did not remember their cocoons for twenty-four hours. On the other hand, a female of Clubiona pallens remembered her eggs for the space of forty-eight hours, and when they were returned to her spun a web over them in the corner of the box in which they were placed. Of all the spiders experimented upon by the Peckhams, the little Lineweaver Theridium globosum had the best memory for her cocoon. This was returned to her after fifty-one hours' separation. She at once went to the eggs, touched them with her legs, then left them to improve her web, every now and then running back to see if they were safe, and presently settled down near them.

A Faithful Mother.

Here, again, our ideas of what might be expected in the ordinary course of Nature are thrown into confusion. The Lycosids, who carry their cocoons about their persons until their young are hatched, and then personally conduct their broodlings until they are strong enough to take their chances in life apart from maternal care, appear to have a weak memory, and a comparatively feeble maternal affection for their offspring. So also the Attids and Thomisids, who remain near their cocoons, brooding or guarding them for the space of fifteen or twenty days, were found so defective, either in memory or maternal feeling, that they lose interest in their cocoons if separated from them for the space of twenty-four hours. No doubt these experiments need supplementing; and when the patient observers who have given us these results shall have wrought longer upon the same field, we may come to different conclusions; but at present it would seem that the development of maternal instincts appears to be quite independent of those causes which, according to the theory of evolution at least, we might have expected to affect them most vigorously.

Development.

IX.

The Peckhams found, as others had discovered, that it is not a difficult matter to deceive spiders as to their proper cocoons. A ball of cotton they

refused, but a little pith ball led them entirely astray. The following will indicate the nature of some of their experiments. A pith ball three times as large as the cocoon of Pardosa pallida was refused by the mother. When reduced in size she took it between her falces and attached it to her abdomen. The bit of pith appeared to give as much satisfaction as the egg sac. When the cocoons were nearly of a size, one mother would take that of another, although of a different genus, just as quickly as she would her own.

Mistakes of Mothers.

As a further test of general intelligence, the outer case was taken from a cocoon of Pallida and slipped over a lead shot of the same size, but three or four times as heavy. Much of the silk envelope was broken away in thus covering the shot, but when offered to the spider she at once seized it and after a good deal of trouble fastened it to her abdomen. The load was so heavy that the mother had great difficulty in walking up the side of a board. While transferring this specimen to another box, the shot from its weight fell from the abdomen, and the mother spent over thirty minutes, working with all her might, fastening it on again. Once more it fell off, and this time she carried it about between the falces and the third pair of legs. A second specimen of this species was tried with the plain shot, but would have nothing to do with it. The web covered shot was then removed from the first specimen, and the plain shot offered to her instead, but this was stubbornly refused, whereupon the web covered shot was returned and was taken back with every evidence of tender emotion.

Lugging a Shot.

Another test was made by offering a cocoon and a pith ball together. The two objects were placed side by side. The mother, approaching one side, first touched the pith ball, and at once seized it with her falces. But as she moved away one of her fore legs touched the cocoon. She stopped, remained quiet a moment or two, then dropped the pith ball, took up the cocoon, and moved away with it. The next day the two objects were again placed in front of her. This time she also happened to meet the pith ball first, and, as before, took it up at once. She ran off with it, and it was some time before the experimenters managed to place the real cocoon just in front of her. As soon as her legs touched this she stood still, and then after a few minutes dropped the pith ball and took up her eggs.

Touch Tells Truly.

From these observations it is evident that the spiders experimented upon, when allowed to choose, can distinguish their own cocoons and have a preference for them. But in the absence of their cocoons they content themselves either with a pith ball or, more strangely still, with a web covered shot. The presence of the web upon the shot makes a marked difference in the disposition of the spider towards it. The contact of the pure metal causes the rejection of the object, while contact with the web covering thereof produces that complacency which leads the mother to

adopt the shot in place of the cocoon. The fact that the spider will carry about so comparatively heavy an object as a lead shot instead of its cocoon certainly argues a poorly developed muscular sense.[1] Sir John Lubbock appears to have made some experiments in the line marked out by the Peckhams, as a result of which he concludes that examples of Lycosa saccata did not appear to recognize their own bags of eggs, but were equally happy if they were interchanged.[2]

Covering Empty Egg Sacs.

A gravid female of Argiope cophinaria sent to me enclosed in a paper box was found dead, having left an unfinished cocoon. She was clinging to one end of a thick patch of white spinningwork that quite enclosed a small tuft of fern leaves, at the other end of which was a roll of purple swathing, corresponding with a purple pad of a complete cocoon. I expected to find the eggs within this roll, but was surprised upon opening it to see a yellowish ball of silk, and nothing more. Where the eggs should have been was only a round silken wad. Nevertheless, the expiring energy of the spider had been spent in spinning a protecting cover around this mock egg mass.

An anonymous observer[3] records somewhat similar cases. He found one Cophinaria cocoon in which there were no eggs, and another containing but three. The eggs were on some boards beneath the cocoon site, having fallen from the first receptacle before they were covered. In each case the mother went on with her work and carefully finished the eggless flask. If the loss was discovered the knowledge made no difference in the exercise of her maternal functions, which, apparently, were controlled by an instinct or feeling quite independent of knowledge.

Unintelligent Instinct.

A like example of mental abstraction (if one may be allowed such a phrase) was reported to me by Mrs. Mary Treat as having occurred at Vineland, New Jersey, with a large Florida Dolomede spider, probably Dolomedes tenebrosus Hentz. This mother, after the habit of her genus, carried her cocoon under her jaw, but sometimes shifted it to a position beneath the abdomen. Yet there were no eggs in the cocoon—a fact which thus came about: When first caught the Dolomede was confined in a tin can, which so surprised or frightened her out of her maternal propriety that she deposited her eggs in the can without attempting to protect them with a cocoon. She was removed to a natural environment upon the ground, whereupon she spun a web and gathered up sundry materials, which she managed to make into the form of a cocoon, which, with this species, is a round sac about the size of a boy's playing marble. This she hugged to her body and lugged about with as zealous care as though it were filled with eggs.

[1] Mental Powers of Spiders, pages 417–419.

[2] On the Senses, Instincts, and Intelligence of Animals, Sir John Lubbock, page 179.

[3] "Katydid," Chicago Tribune, September 11th, 1881.

Evidently in this case, as with the Argiopes, the mother acted under the impulse of a mentalism that was without reasoning; or, if we may suppose that she reflected upon the loss of her eggs, such reflection had not sufficient influence upon her will to resist the instinctive impulse—or shall we say the simple functional impulse?—to brood upon something. These cases remind one of the well known persistence of setting hens in brooding over an empty nest.

Tegenaria.

The English observer, Mr. F. M. Campbell, records a like example. While watching a female Tegenaria guyonii lay her eggs, it occurred to him to see what she would do if these were removed. Accordingly the eggs were deftly lifted away, but somewhat to the disturbance of the mother. After a few seconds she began to overspin the spot where she had just placed her eggs, and completed her cocoon.[1] Mr. Campbell's suggestion, that the force of habit urged forward the aranead to act as though the eggs were in the proper site, must be qualified by the fact that "habit" cannot have much influence in a maternal act which is repeated so few times as with this species. There is more plausibility in the physiological aspect of the act which he suggests, viz., that the maturity of the eggs may have been correlated with greater activity in the collection of fluid by the spinning glands; and, as in the case of the mammæ of a vertebrate, the discharge of their contents may have been necessary for the comfort of the creature.

X.

Intuitive Skill.

It is impossible not to note the many evidences of exact mechanical skill and design shown by spiders in the act of cocooning. We speak of this, no doubt properly, as instinctive. Certainly it is not the result of experience, for even in the case of those spiders that make several cocoons, the first one is finished with the same accuracy, and indeed after the same methods, as the last. It cannot result from instruction, for in the great majority of cases the young are never associated with their mother; and in those cases, as among Saltigrades and Lycosids, where the spiderlings are under maternal watch for a little season after hatching, the idea of instruction in the art of cocoon making is not to be thought of. Neither can we suppose this remarkable mechanical accuracy to be the result of observation, though no doubt it might happen that immature females observe the methods of cocooning practiced by mature specimens of the various families. In short, the only admissible conception is that the act, including all the methodical details, is intuitive, and springs into being in full operation at the moment that it is needed, and that without any previous preparation or knowledge of any sort on the part of the aranead mother.

[1] On Instinct, Trans. Hertfordshire Natural Hist. Society, Vol. III., page 3, Dec., 1884.

Nevertheless, it must be admitted that the entire actions of the spider are such as one would expect from an individual that had been thoroughly instructed, had acquired skill from experience, and was pursuing a matured plan with all the evidences of forethought and skill. To illustrate this fact, one may refer to the method practiced by Argiope in making her cocoon. Nothing could be more indicative of forethought than the manner of placing the eggs at the outset upon the little saucer shaped disk prepared for their reception, and which are retained in their place by means of the silken sac swiftly woven over them. The preparation of the thick padded purple mass which next envelops this strikes our attention as indicating wise skill. The manner in which this is woven so as to produce the loose substance that envelops the eggs, and at the same time is compacted into a solid and shapely mass, is certainly what the artisan might denominate a "mechanical job."

Marks of Forethought.

Then, again, contrast the mode of weaving this object with that practiced upon the external case of the cocoon. As has been shown in full detail, the method of spinning is here quite different, and corresponds closely with the character of the fibre to be spun. In other words, as it is the intention of the mother to make the outer case a closely woven tissue, instead of a loose mass like the purple pad above alluded to, she proceeds to tighten the threads, bracing them upon each other and compacting them by all the methods familiar to her spinning art.

Nor can we fail to mention here the manner in which the service is equalized so that every part is of nearly equal thickness and evenly distributed, so as to form the shapely pyriform cocoon familiar to most wanderers in our fields. As has been explained, this is done by carrying the silken filaments as they are outspun from point to point while the spider circumambulates the surface. That such a practice requires a directing purpose, and that such a method is the outcome of an express design, seems the most manifest conclusion. The spider spins her cocoon case very much after the manner in which a lady winds up a ball of silken thread or of embroidering wool. One would think it as unreasonable to say that the manner in which the ball in the lady's hand is shaped into its globular form is without any directing purpose on her part, as that the mother Argiope, in forming her cocoon ball, wraps the silken material of which it is composed without any guiding purpose to keep it even.

Take another example, to illustrate this point, the remarkable mud ball of Micaria limicunæ. The cocoon sac has been shown to be a white oval case within which the eggs are spun, and which is connected to some surface by a little silken cord or pedicle attached to the top. This sac made, the spider proceeds to cover it with mud, and so works that, when she has finished, the enclosing shell of mortar is, with scarcely an exception in a large number of specimens examined, a well rounded globe. Now, how has the spider proceeded to

The Mud Cradle Maker.

accomplish this result? If we were to suppose a human plasterer given the task of covering a sack hung to the ceiling of a roof with a coating of mortar two or three times the bulk of the sack, and to have the same, at the conclusion of the work, in the shape of a globe, how would he proceed? Manifestly by placing successive layers around the sack, suffering one to harden before the other would be laid on, rounding each up with his trowel as he proceeded, building the mortar around the cord by which the sack was suspended, and all the while so guiding his implement that the object would gradually assume the globular shape required.

Precisely such is the method pursued by our little Limicunæ. A dissection of the cocoon shows that the spider placed her mud upon the silken sac in numerous successive layers; that she permitted one layer to harden before the other was laid on; and that, as she gradually proceeded, she built her mortar around the suspensory cord or pedicle, and shaped the whole with her mandibles and feet until it assumed the form of the smooth, round object represented in Figs. 147 and 148 on page 130.

Limicunæ's Method.

One cannot venture to think that the process by which the human plasterer arrives at his method of work is identical with that pursued by this spider plasterer. In the one case it is the result of education and experience, and of the application by reasoning of previous training to the problem in hand. In the case of the spider no such education or experience, and probably no such process of reasoning, can be predicated. What mental processes has she gone through, if indeed she has passed through any? Can we ascribe to her, under the circumstances, the credit of reasoning upon her work and adapting her methods thereto? To do this would seem to me to place her thinking abilities and natural mechanical capabilities above those of man. That there have been design and forethought somewhere behind all the processes of the spider mother one cannot doubt; yet with equal certainty we must refuse to attribute them solely to the spider herself. Forethought and mechanical skill abide in Nature, whose formative forces have wrought out the structure of the spider and guided all its functions. But forethought and skill are the attributes of mind, of personality; and how shall we denominate this Personal Thinker? How can we deny His Presence?

Man's Method and the Spider's.

Perhaps a third illustration may be added. Cyclosa caudata has the curious habit of attaching to the exterior of her cocoons carcasses of insects from which she has sucked the juices, instead of casting them from the snare, the usual aranead mode of disposing of such material. Given the habit of suspending the cocoon within the disc of the orbicular snare, and also the habit of protecting the same by an armor of extraneous material, it is, perhaps, inevitable that the mother should be compelled to resort to some such method. It is

Cyclosa caudata.

obviously impracticable to descend to the ground and secure mud, vegetable mould, and chippage, as is the custom with those species whose cocoons are fixed upon various surfaces, and whose makers can conveniently resort to terra firma. In the case of our little Caudata, whose net swings in the open air, the chippage of slaughtered insects is after all the most convenient material at hand. Necessity here, as among human creatures, appears to have been the mother of invention, aided much by opportunity. The hard, dry shells are cut up into pieces, which are stuck to every part of the egg sac until the whole is covered, often very closely. Thus, in a single cocoon one will be able to detect the wings, head, elytra, abdomens, and other parts of various orders of insects, many of them having bright colors.

In these various methods of exercising this general habit one can find no motive which meets the facts of the case as well as that of maternal solicitude. Mother love has found expression in the armoring of the silken vessel within which the eggs are enclosed, thus protecting them from the enemies which are to beset them. The motive is none the less potent, and none the less to be recognized, because of the fact that the mother herself could have had no knowledge of the character of those enemies to which her progeny would be exposed, and acted in obedience to an impulse within which we can trace no factor of personal reasoning.

PART III.—EARLY LIFE AND DISTRIBUTION OF SPECIES.

CHAPTER VIII.

COCOON LIFE AND BABYHOOD.

I.

THE tyro in arachnology experiences his first and greatest difficulty in the attempt to separate between the mature and immature spiders collected by him. There are resemblances between the young of various species, particularly of the same genera; and the differences between the young and the adult of any one species are, in certain cases, so great as to produce confusion. In point of fact, except for purposes of special study in life economy, young spiders are not worth collecting or retaining in a collection. The valuable specimens are only those which are mature.

Adult and Young.

Now, it must be remembered that spiders do not undergo a metamorphosis—a fact which is continually forgotten because of their classification with insects by the earlier writers, and the frequent treatment of them under Entomology even at the present day. Certain orders of insects, as the Lepidoptera, undergo a complete metamorphosis. The butterfly arrives at maturity through the well marked stages of the caterpillar and chrysalis. Other orders, as the Orthoptera—locusts and grasshoppers, for example—have an incomplete metamorphosis. But a spider is a perfect animal from its birth, and only requires the general growth and strengthening of its members, together with the development of the sexual organs, to complete its maturity.

Spiders Without Metamorphosis.

This maturity is reached after several successive moultings of the skin. An important outward structural change takes place at the final moult, at which time male spiders get their complete armature of spines, bristles, and hairs, according to their species. Moreover, the last or digital joints of the palps, which, to quote the language of Cambridge,[1] have been up to that time tumid and homogeneous, break up into the digital joint, so

[1] "Spiders of Dorset," Introduction, page 26.

Moulting and Maturity.

called, and the curious and more or less complete congeries of lobes, bulbs, and spines known as the palpal organs. The full dimensions of the legs are also sometimes attained at the same period. The female spider at her last moult merely develops the genital aperture with its external processes. Up to this time the aperture is invisible, though, like the palpal organs of the male, it has been gradually developing beneath the cuticle.

II.

Cocoon Life.

Of spider life within the cocoon our knowledge must necessarily be limited. The period of hatching differs according to the species, the time of the year, and the nature of the season. The eggs in many autumn cocoons do not hatch until spring, say from the middle of April to the middle of May. I have gathered many cocoons that have wintered out of doors, of Agalena nævia, of various Laterigrades, and several species of Orbweavers, which contained unhatched eggs from which young spiders were subsequently bred. After hatching, the little creatures remain massed within the cocoon along with the white shell of the egg or the first moult. At times they spin delicate threads, which add to the flossy nest within which they domicile, so that after a cocoon has been opened for examination, the fracture will be closed up by such spinningwork.

Period of Hatching.

The spring or summer cocoons are hatched at periods varying from fifteen to thirty days. According to Professor Wilder, the eggs of Nephila plumipes laid in September were hatched in about thirty days.[1] A cocoon of Epeira cornigera, taken in April and having the eggs then unhatched, I found to contain fully hatched young on May 15th. A female Epeira sclopetaria cocooned in a trying box May 26th, and on June 13th, eighteen days thereafter, the young brood issued from the cocoon.

I have opened cocoons of Argiope cophinaria in the early winter, and found the young within crawling about in a sluggish way among the silken fibres of the interior enswathment, or massed inside the central, common pouch along with the white skins of their first moult. On the contrary, I have found cocoons in which, as late as April 20th, the young had just cast off the egg shell, and were beginning their first, feeble movements in struggling with the silken lines of their enswathment. I have little doubt that the young of Argiope are generally hatched from the egg within a month or six weeks after the cocoon has been made. They, therefore, remain within the cocoon during the winter and until the season is sufficiently advanced to make their egress safe.

[1] Proceedings American Academy of Arts and Sciences, Vol. VII., 1866, page 56.

But in the case of females who, for whatever reason, have been belated in positing their eggs, the frosts of early autumn probably have the effect of retarding the process of development; and when the later autumn frosts and the winter cold follow, the eggs of such cocoons remain unhatched until the first warm days of coming spring quicken their vitality. This is probably true of other species than Argiope. I have never made any experiments upon the effect of frost to retard or prevent the hatching of spider eggs, but am inclined to think that cold has this effect upon them, as it is known to have upon the development of insects.

Effect of Cold.

On May 22d, one exceedingly cold season, I found the young of Epeira sclopetaria, at Atlantic City, all escaped from their cocoons, great numbers of which were fixed upon the cornices of various buildings around the Inlet wharf. At the same time many cocoons of Epeira triaranea had the young still within them. I have had young Insular spiders colonized upon my vines make their exode May 19th.

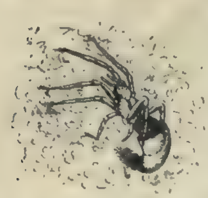


FIG. 241. Young Agalena stripping off the first moult.

M. Vinson says that July 1st Gasteracantha bourbonica, a Madagascar species, enclosed in a flagon, had fixed her cocoon against the side. On the 25th the little spiders were hatched. They were perfect as to their forms, but were still imprisoned within the cocoon. They presented a blackish appearance. They issued from the cocoon and scattered on the 11th of August, a period of seventeen days after hatching. So that under an African winter the hatching of eggs and escape of the young occupies a period of forty days.

On the disengagement of young spiders from the egg every part is enclosed in a membranous envelope; they are embarrassed in their movements; are unable to spin or seize prey, and seem indisposed to action. For the unrestrained exercise of these functions it is requisite that they should extricate themselves from the covering which impedes them. This operation, or, as it may be termed, their first moult, occurs after a period whose duration is regulated principally by the temperature and moisture of the atmosphere. The first moult invariably takes place in the cocoon, or general envelope of the eggs, and the young spiders do not quit the common nest until the weather is mild and genial.[1]

First Moult.

Once, while peeping inside a cocoon of Agalena nævia, I was fortunate enough to observe a spiderling in the last stages of this first moult. While it held on to the flossy nest with the two front and third pairs of legs, the hind pair was drawn up and forward, and the feet grasped the upper margin of the sack like shell, which, when first seen, was

[1] Blackwall, "Spiders of Great Britain and Ireland," Intro., page 6.

about half way removed from the abdomen. The feet pushed downward, and at the same time the abdomen appeared to be pulled upward, until the white pouch was gradually worked off. (Fig. 241.) The motion was not unlike that of a child stripping off its night dress by pushing it down the body and stepping out from the drapery.

Life within the cocoon is not wholly destitute of "moving accidents" and "hairbreadth 'scapes," if we may believe Professor Wilder, who argues that the young of Argiope cophinaria eat one another while yet within cocoon limits. His reason is that a comparison of the contents of cocoons opened early in the season with those opened later showed that the spiderlings were fewer in number but larger in size.[1] He infers the same thing from the fact that after egress the young do prey upon one another, but without sufficient ground, as the one fact by no means implies the other. My own observation has been, of all species, that the young live together peacefully while within the cocoon. However, I have chiefly studied the cocoonery of our more northern latitudes.

Cocoon Cannibalism.

In southern latitudes, where the hatching probably occurs earlier with some species, and the period of confinement after hatching is thus much prolonged, or the appetite of the young quickened by the climate, hunger may assert its supremacy. Yet, even in the case of some southern spiders, as examples of Zilla from southern California, reared during winter in my study under conditions of temperature not very different from their native latitude, there never appeared a trace of cannibalism until after the young araneads had woven their first independent snares. In the case of most, probably of all, species in our more northern climate, during the greater part of the four months intervening between hatching and egress, the young are probably more or less torpid by reason of the cold, and thus with natural appetite still in abeyance. Even in our Southern States the influence of season is seen by a general suspension of activity in the insect and aranead world; and, independent of climatic influence, Nature doubtless gives a semidormant tone to the spider young.

Whatever may be the truth as to Argiope and Nephila, I am certain that many species do not have this cannibal habit within the cocoon, nor, indeed, for some time after egress therefrom. Mr. Pollock's observations[2] of Argiope aurelia, of Madeira, quite correspond with this statement, for the broods were always friendly within the cocoon, and indeed for a fortnight after leaving it.

III.

The spiderlings themselves procure exit from the cocoon in most species. This is frequently accomplished by cutting a small opening through

[1] Proceed. Am. Asso., VII., 1873, page 260. [2] Ann. and Mag. Nat. Hist., 1865, page 460.

the outer envelopes. (Figs. 242, 243.) I have noted these openings in cocoons of Agalena nævia which were under observation for that purpose; the period at which the openings were cut was identified, and the little inmates seen peeping out at the round doors, of which there were, in some cases, a number opened, from which also they escaped when the cocoon was agitated. Similar openings have frequently been observed in the cocoons of Argiope cophinaria, Epeira cornigera, Argyrodes trigonum, and in numerous examples of Epeiroid, Tubitelarian, and Laterigrade cocoons. In these, however, as a rule, there was only one opening, but sometimes two.

Egress from Cocoon.

Professor Wilder has recorded some facts upon this point.[1] Cocoons of the Basket Argiope kept by him in South Carolina were never seen to be pierced by the inmates. Of four hundred and six cocoons obtained on James Island in the spring of 1865, only one hundred and thirty-four were entire, presenting no opening whatever. Of the others one hundred and ninety were pierced when found, but no spiders came out of these before May 10th. The openings in them were similar to that made in a New York cocoon June 14th, by the inmates themselves. This hole was near the pedicle or stem of the cocoon, and from it the young escaped. Of the remaining eighty-two cocoons fifty-nine were torn in one or more places, and loose silk proceeded through the rents. Professor Wilder once saw a little bird, about the size of a sparrow, fly at a cocoon hanging in a tree, make one or two quick pulls and then retreat. He is therefore inclined to think that all the above rents were so caused; and, as these attacks would usually open the cocoon without injuring the inmates, he drew the inference that this might be a provision of Nature, somewhat like the fertilization of flowers by insects, by which the invasion of the cocoon should really permit the continuance of the species.

Argiope cophinaria Cocoons.

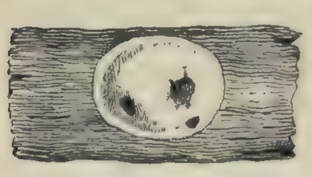


Fig. 242.

Fig. 243.

Drassid cocoons, to show the openings out of which the young have escaped.

Fig. 242. Front view. Fig. 243. Side view.

There may be some ground for this inference, but it is certain that in ordinary cases no such external provision is required. Birds are much disposed to use the silken material of spider cocoonery for their nest building operations. Mr. Thomas Meehan, the botanist, has seen the pewit engaged in collecting spider's spinningwork on his grounds at Germantown. Hummingbirds are known to make large draughts upon spider webs for nest building material. I have in my collection

Delivery by Birds.

[1] Proceed. Am. Assoc., 1873, page 260.

several nests built by a Vireo, the white eyed Vireo probably (Vireo novoboracensis), which are largely composed of the thick sheetings taken apparently from the cocoons of various Orbweavers and the Speckled Agalena, which may all have been abandoned cocoons. However, it is extremely probable that some of them were filled with young spiders when seized. Such seizure would not necessarily prove fatal to the young, as I have demonstrated by experiment, substituting my fingers for the bill of a bird.

At the first pull, or as soon as a fracture had been made, a number of the wee fellows would run from the cocoon hurry-skurry and take refuge under surrounding objects. When a pinch or two more had widened the fracture so as to allow the brood to escape freely, and the hand was swung upward through the air as nearly as might be after the manner of the supposed robber bird, a long trail of young spiders floated behind, all hanging on as for dear life to the filaments that streamed backward like a kite tail, and which were the united threads of the whole evicted tenantry forced into the utmost activity of their spinning organs.

Nearest to the fingers the filaments were thickly placed, and here the young balloonists were massed. Further on they were less in number, and so to the end of this curious pennant, where one or two clung to the tapering point of gossamer. Of course, during the rapid motion some of the spiderlings were detached from the mass and floated away upon single or manifold strands. It is thus easy to see that a bird carrying a torn cocoon under similar circumstances might distribute a large portion of a brood along the course of her flight without destroying many. Even for those remaining within the cocoon or clinging to the shreds thereof, there would be good chance to escape scot free after the work of weaving the silken material into the nest should begin. The action of birds in opening cocoons is an accident of which spiderlings doubtless avail themselves, but it probably goes for little or nothing in the natural delivery of the brood; and the peculiar spinning habit of spiders tends to protect them from the violence of such attacks when made.

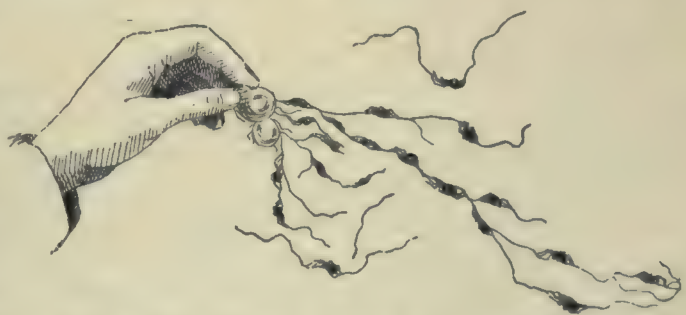


FIG. 244. Young Agalenas escaping from a plundered cocoon.

Mrs. Mary Treat has informed me that the young of Argiope cophinaria have been observed by her escaping through the pedicle or stem of the outer cocoon case. A reference to the figures of the cocoons of this species in Chapter V. will show how this is done. The pedicle of

the cocoon is a short hollow tube. Just below this tube on the inside is hung a funnel shaped silken cap, which is attached above to a strong silken cord composed of numerous fibres, which cord passes upward through the hollow stem, sometimes forming an outward attachment to some external object. It would not be a difficult task for the young Argiopes to work their way between the inner wall of the cocoon case and this cap above described, and so along the cord and out into the air through the pedicle. If Mrs. Treat's observation should be established as a common habit, it would, of course, account for the fact that Professor Wilder found so many of these cocoons without any external opening. Simply, the spiders had crawled out through the pedicle; but I believe this is not common.

Egress of Argiope's Young.

In the case of many cocoons spun by Epeira, and, indeed, by Orbweavers generally, there always is a selvage uniting the upper to the lower portions of the outer case. As the spiders grow and the period for egress approaches, this selvage appears to open, a result which is perhaps due in large part to the influence of weather and time in loosening the tension of the threads which close the edges of the parts. Through this open selvage the spiders are enabled to escape with comparative ease. Even were there no relaxing of tension in the uniting threads, it would be easier for the spiderlings to cut their way out from this part of the cocoon than through the unbroken parts. A reference to several of the cocoons described in Chapter V. will show this.

The Selvage Door.

It remains to be determined whether the mother in some species may not be an active agent in delivering or aiding the deliverance of the brood. Emerton once noticed a small Theridium gnawing at its soft cocoon, and found that one side had in this way been made much thinner than the remaining parts. He placed the spider with her cocoon in a bottle, where he could watch her. She soon recommenced the biting, and kept it up during the remainder of the day. The following night the young came out. Of course such a habit could only appear among those species that brood or watch over their cocoons until the young are hatched, or among those who, like various Theridioids and such Orbweavers as the Labyrinth and Tailed spiders, make several cocoons and string them within their snares. As most cocoons are abandoned by the mother immediately after spinning, the enclosed young must escape without maternal aid.[1]

Delivery by Mother Aid.

Menge observes that the warm rays of the spring sun awaken the germ of the eggs, and by the time Mother Nature has provided a plentiful supply of flies and mosquitoes, the young hatch. It is a peculiarity of spiders that they do not leave the egg nest at once, but remain until legs, palps,

[1] "Structure and Habits of Spiders," page 104.

skin, and all parts are perfected. By this time the body is covered with hair and they possess claws and bristles; they crawl about and begin to spin, but remain in the neighborhood of the cocoon. They have as yet no need for food, as sufficient yelk is deposited in their bodies for present wants.

After six or eight days the second moulting takes place, and they now begin to feel hungry, and, when nothing else offers, attack each other, the strong devouring the weak. Menge also noticed that when kept imprisoned they will even eat the old skin; but when at liberty neither of these extreme measures take place, as a general thing, inasmuch as plenty of food is found around the place of their birth. At this time each aranead supports itself as Nature ordained, and, its appetite becoming ravenous, it rapidly increases in size and development. For this reason Menge never succeeded in carrying young ones, hatched in a glass, over this period and he doubts whether it can be done at all, even taking foreign varieties (such as American) for the purpose. He tried Le Bon's experiment, feeding them from quills filled with blood of young pigeons, but without success. A few of them may suck the blood, but most of them pay no attention whatever to this unnaturally served food. Most grown spiders present the same difficulty, preferring to starve to death rather than accept food which they do not fancy; even the very insects on which they live when free are refused if not caught by themselves.

Artificial Rearing Difficult.

Menge often tried to bring to maturity a yet undescribed spider (Melanophora), which he found rarely, and always full grown; but in this he failed. Although the glass was filled with flies, mosquitoes, podura, etc., the spider left them untouched, and finally both insects and spider died. The same result attended efforts with Saltigrades. Lineweavers and Tubeweavers were much easier to feed, as they attack everything that falls into their web when not too large or too much against their taste. The easiest to keep in captivity are the Lycosids, which become tame and will take flies offered to them in the hand.[1]

IV.

Open Air Life.

After the rigors of winter have been successfully endured, the warm days of spring first hasten the process of hatching, and then tempt the spiderlings from their cocoon. I have repeatedly observed, during a series of years, the issuing of broods and their behavior immediately thereafter. The observations have been under favorable conditions within doors, and also out of doors from cocoons transferred from their original site and affixed to branches of shrubbery, and a few in original site. The young of various species representing Orbweavers,

[1] Menge, "Preussische Spinnen."

Tubeweavers, and Laterigrades, especially, have been studied. The results from experimental hatching are but little different from those which everywhere transpire in Nature, and, taken together with numerous facts noted afield, enable us to accurately sketch the life of the infant spider just after deliverance from the cocoon.

First Days of Outdoor Life.

One example, followed consecutively, will illustrate the habits of Orbweavers. Early in May a cocoon of Epeira insularis was taken from a tree on the banks of the Schuylkill. It had been placed by the mother spider on the under side of a branch, where it was best protected from the weather, and consisted externally of a ball of thick, yellow, curled floss, about one-half an inch in diameter. (Fig. 245, C.) This was attached to the limb by a thin coating of white tissue, from which short, strong cords entered the ball. Within the ball were about one hundred young spiders, just fully hatched. The cocoon was placed in a paper box, and the spiderlings remained shut up in it until May 13th. Meanwhile they had made their first moult. This cocoon was now opened and put within a large covered paper box, which, by a dent in the side, had free communication with the outside. Next morning I found that the spiderlings had issued from the box and woven a mass of delicate webbing over the surrounding objects upon the table. The lines were most closely spun near the points of exit, where they resembled a delicate tissue web. They were carried along the table on one side to a distance of five feet, on another of two feet, and the lines decreased in number as the distance increased. Where threads were dense the spiderlings were massed (O, Fig. 246) in large numbers, and as the lines thinned out the numbers decreased, until at each of the two points where the spinningwork ceased were one or two pioneers engaged in pushing the lines further from the centre.

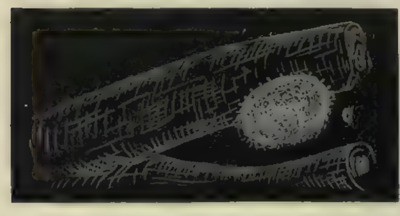


FIG. 245. Cocoon (C) of Insular spider, on the under side of a twig.

Distribution of Species.

In point of fact, this last sentence expresses the general instinct which controls the young on their first issue from the cocoon—they spin away, and away from the home cradle, restlessly further and further, until they are arrested by satisfactory surroundings and further flight is hindered, or until they pause to undergo another moult. This is undoubtedly the impulse bestowed by Nature for the dispersion of the brood, with a view to the distribution and preservation of the species, primarily, perhaps, to the preservation of the young from their own cannibal propensities. In order to test this matter and decide the mode of procedure, I fixed attention upon one of the outposts. Three feet from the main assembly (O, Fig. 246) a single straggler had carried or followed a line.

A toy column from a box of a child's building blocks was placed eight inches from the point reached by the spiderling, in order to arrest the thread which I believed she would emit. Directing a magnifying glass upon her, I presently saw her assume the attitude common to her

FIG. 246. Assembly of spiderlings when first escaped from cocoon. O, the maze of crossed lines found outside of box; V, the furthest limit of same.

order when about to take aeronautic flight. The eight legs were spread in a circle, the abdomen elevated, and from the spinnerets issued a delicate gossamer line, which was carried to and fro in the slight currents prevailing even in a closed room. Quite soon the line entangled upon the top of the column. Just as the spider was about to adventure upon her tiny bridge, a sister broodling reached her, at the touch of whose foot she instantly dropped downward along the side of the table and hung, back underneath, by the emitted line. (Fig. 247, 1.) Meanwhile the new comer unhesitatingly mounted the bridge line and crossed over the column. (Fig. 247, 2.) The journey was made "hand over hand," to use a not inappropriate figure, and with the back downward, the invariable posture of all spiders on like occasions. The original pioneer now reascended, and straightway followed her predecessor. At this stage I was summoned from the room by a visitor, and when I returned, in half an hour, a colony of fifty-three spiders had been drained from the mass meeting at O, Fig. 246, four feet distant, and were spread over a series of open lines woven into a triangular network fence (Fig. 248, F), into which the original line had now expanded.

FIG. 247. Young Epeira practicing the drop dodge of making a foot basket.

This illustrates another marked tendency of the earliest movements, viz., the bulk of the colony follow the pioneers, and group themselves near together; in other words, they are at this stage gregarious. This action was repeated a number of times during the next three days. I found that I could always transfer the group to any chosen spot by placing thereon some elevated object. For example, I put a second column at y (Fig. 248), eight inches from the first column (x), and then pushed a toy dancing puppet (z) across the table eighteen inches distant from x. In order to

test the effect of a current of air, I slightly raised an adjoining window, admitting a light play of wind across the fence on the column x. In three minutes two lines were fastened upon the cap of the puppet, and two spiders had begun to cross from the points marked 2, 3. These lines were so delicate that I had not seen them until the motion of the spiders along invisible bridges directed particular attention to the spots. Within an hour all the colony but two had crossed over the fence (F) to the puppet, and were swarmed around the head, face, and chest of the figure, and upon a mass of lines (n) that stretched to a wire (w). A triangular bridge of lines (B) had now been formed, whose apex was the head of the puppet (z), and which broadened out, touching the columns (y and x) and connecting with the first perpendicular bridge (F) by the three principal points (1, 2, 3) from which the migration had proceeded.

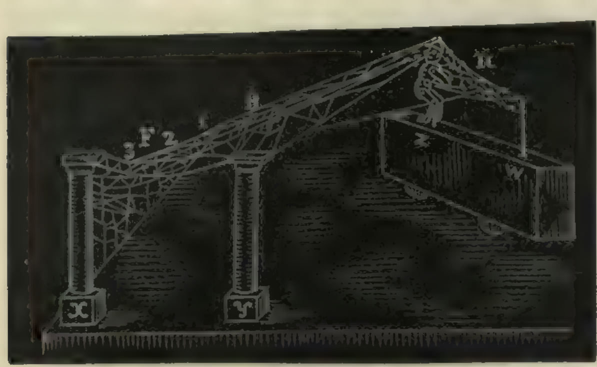


FIG. 248. Migration instinct. F, fence of netted lines; 1, 2, 3, points of first departure; B, bridge lines for transit; n, final assembly of spiderlings.

Gregarious Habit.

In the course of three days, by arranging various elevated objects over the table, and breaking off the threads that floated beyond the prescribed limits, I had induced the brood to cover a space having a linear boundary of about twelve feet. The greater portion of the area thus bounded became at last sheeted by a web composed of the innumerable lines emitted by the little spinners, so that the whole presented a quite good miniature of the canvas tents of a traveling circus company.

For long periods the little creatures would hang quite still, separated from each other by distances varying from three-fourths of an inch to one, two, and three inches. In these resting moments they hung inverted between two lines which they grasped respectively by the four feet on either side; the abdomen was elevated somewhat, a short thread issued from the spinnerets, and was attached to an upper line, thus helping to support the body. (Fig. 249, 1.) Occasionally the two hind legs grasped a cross line hung upon or above the parallels, and the thread from the spinnerets was also attached to the cross line. (Fig. 249, 2.)

Position in Rest.

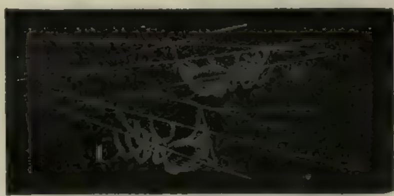


FIG. 249. Position of spiderlings when at rest upon assembly lines.

A number of cocoons forwarded to me in the early spring, by Mrs. Eigenmann, from San Diego, California, gave me an opportunity to note the tendency of young Orbweavers in outdoor site. The cocoons were fixed upon bushes within the forks of branches, at the time when the young were just ready to escape. They evidently felt the fresh air of the open, as contrasted with the boxes in which they had been confined, and at once pushed their way from the flossy interior to the outside of the cocoon. Then one adventurous spirit scrambled to a branch and began to ascend a stem. Another and another followed, each trailing a dragline along the surface, until at last several threads were merged into one, which the little creatures laid hold of as succeeding numbers emerged from the cocoon. Thus a long line of them appeared climbing up the thread, which at places swung free from the stem, and at others hugged it closely. (Fig. 250.) They reminded me of a watch of sailors following each other up the shrouds of a ship.

Escaping from Cocoon.

Fig. 250. Cocoon fixed upon a rose bush, and spiderlings issuing therefrom. To show tendency to ascend and migrate.

Here and there, at various points, individuals would strike out an independent line of progress, and would be sure to be followed by some of their comrades. One might be seen dangling from a leaf by a slender filament; another with elevated abdomen sending out the first lines of a tentative balloon; a third already embarked on an aeronautic venture, swinging free and swaying in the breeze. (Fig. 250.) The general tendency was to ascend; scarcely a spider went below the point at which the egg sac was fixed. Here and there little groups would form and hang back downward for a while by a few crossed threads; these again would break up, and at last, well toward the summit of the bush, the colony, with the exception of a few independent characters, massed themselves under a leafy shelter, and so remained pendent like a ball—legs, palps, heads, and abdomens mingled in a confused mass. (Figs. 251, 252.) This I suppose to be a good example of the general habit at this period. The "balling" or "snugging" of the brood is quite sure to suggest to the observer the appearance of a swarm of bees just escaped from the home hive.

First Movement to Ascend.

How long does the brood remain thus massed? This depends greatly upon circumstances, particularly the velocity of the wind and temperature of the air. A brisk wind and fair day tended to scatter my experimental spiderlings very rapidly; indeed, during the afternoon and night. This will best be illustrated by the following case.

Balling.

V.

An interesting example of the habit of young spiderlings immediately after escape from the cocoon, was seen May 23d, 1887, in a ravine upon the ground of Ogontz, a young ladies' school in the vicinity of Philadelphia. When observed, the little creatures were snugged together in a ball underneath a large leaf of Indian turnip or Jack-in-the-pulpit (Arisæma triphyllum). Two smaller individuals of the same plant stood on either flank. The tall central plant served as a sort of tent pole, and from the margins of the broad top leaves a delicate silken tissue spread downward to the edges of the shorter Jacks mentioned. There was thus formed a symmetrical pavilion, within which the spiderlings were contained, and which presented all the appearance of having been constructed intentionally. I am confident, however, that the delicate canvas wall of this tiny tent was simply formed by the immensely multiplied threadlets which the colony continually dragged after them as they moved back and forth, up and down, in the preparatory stages of settling themselves.

A Tented Colony.

When first observed, the whole colony was massed in a ball as large as a walnut underneath one of the top leaves. The spiders were of a yellowish brown color, and gave a pretty appearance as seen through the silvery-white of the silken wall against the green background of their tent roof. When I tapped lightly upon the top of the leaf beneath which they were snugged, the ball instantly broke up, and a hundred or more of the little fellows dropped swiftly downward. Every one dragged after it a silken attachment, which filled the inside of the pavilion with perpendicular lines. Most of the number returned in a little while to their position. Some remained hanging at various distances; a few who had fallen quite to the bottom of the tent, which was limited by the top leaves of the two flanking Jack-in-the-pulpits, ran out from under the edge of the tent and extended their excursion for a little distance beyond.

Dispersion.

When I left the brood, Miss Skinner, the teacher of natural history in Ogontz, kindly consented to keep it under observation, and I am indebted to her for the following history prolonged through a period of ten days: The colony was first observed on the morning of May 23d. The next day was rainy and windy. On the 25th it was found that great rifts had been made in the overhanging web or pavilion wall on the leeward side;

FIG. 251. The tent and assembly of young spiders beneath a leaf of Jack-in-the-pulpit, on the grounds of Ogontz Seminary.

while on the windward side it was quite swept away. To quote the moralizing sentiment of the journalist, "their frail house was more ragged than good resolutions after a week's wear!" The spiderlings remained snugged underneath their leaf as when first seen.

Shedding First Coats.

On the afternoon of May 27th the little fellows had "outgrown their clothes, and hung them on the line, while they looked very smart in their new clothes, over which no one had toiled. Their change of garments had led to no change of habits," for they were snugged together in a ball as when first observed. In other words, the spiderlings had undergone a moult, and their white casts of skins clung to the lines upon which the moult had been effected. This is usual among young spiders. Mrs. Treat has even observed the shed skins of baby Turret spiders[1] clinging to lines stretched across the top of the mother's abdomen, upon which the younglings had unfrocked themselves.

Dispersion.

May 29th, 9 A. M. The colonists were still closely snugged. They had grown some, and had thrown out a few cables to support their tent, which was then quite rickety. At five o'clock in the evening they were in the same condition. May 30th, 5 P. M. A few individuals were found spinning webs on an adjoining tree, but the majority were "wandering in the wilderness of life, and could not be found." Twenty-one still clung to the old home. * * * May 31st, at 2 P. M., only five spiderlings could be found. "These wandered about in a forlorn way like pilgrims preparing to seek a shrine beyond the known country."

June 1st, at 3 P. M., not one of the colony was to be found. The fragments of the web and "the old clothes" were all that were left. About a rod beyond the site of this colony Miss Skinner found a new ball of spiderlings, apparently quite recently made; I quote the conclusion of her journal, which relates to this second colony: "June 2d. Something has happened to them, I know not what! Not a trace is to be found. So perish great nations!"

Two of the young ladies of the seminary made sketches of the colony two or three days after the first observation. At that time the enclosing pavilion had been blown away, nothing remaining but a few straggling lines. I have restored the pavilion from my own sketch, presenting it thus as when first seen. (Fig. 251.) There is nothing to show how many of the two Ogontz colonies may have survived. It is not unlikely that a few scattered into the surrounding foliage and might have been found quietly ensconced beneath leaves or any other sheltered position, but the probability is that most, if not all, of them perished. Such is certainly the fate of multitudes of young Orbweavers.[2]

---

[1] Lycosa arenicola Scudder. See the author's "Tenants of an Old Farm," page 139.

[2] I reserve for the chapter on General Habits (under Moulting) the history of a brood of Epeiras hatched upon a honeysuckle arbor in my manse yard, whose fortunes I followed with particular interest.

One of the young ladies in the natural history class of the school wrote and published in the "Ogontz Mosaic" a versified account of the above colony, which I venture to add, as a pleasant description of and happy comment upon the incident. It may at least serve to brighten for a moment the dullness of these pages of details, and show that one may find a gleam of poetic fancy even in the babyhood of despised Arachne's children.

THE CHILDREN OF THE SPIDER WEB.

UNDER a Jack-in-the-pulpit's care,
Where the shadows are deep, and the sunlight rare
Tenderly kisses the maiden hair,
A loving mother made her nest,
And never did rest
Till flossy blankets and silken sheet
Enclosed her eggs in a safe retreat.
The brood was safe, but the mother dead,
For love's last act spent life's last thread,
And the fair cocoon was left to swing
Till winter's snow dissolved in spring.
The air was warm and the sunshine soft;
To and fro the breezes tossed
The tiny hammock of shining threads,
Of shimmering, silvery spider webs.
Far from the sounds of war and strife
Were the spider babies wooed to life.
On one bright day they all awoke,
Their prison doors they burst and broke;
And, peeping through the barriers white,
Discovered a wonderful world of light.
With glad surprise they looked around,
Then a daring one, with a single bound,
Went dancing down on a tiny thread,
Making his own little spider web.
        Graceful and airy,
        A real fairy,
He entered this new found land of glory.

The days went by, and the babies grew.
Were their pleasures many, their sorrows few?
Or within the silken canopy
Was there acted out a tragedy?
* * * * * *
        Shall we e'er know the source
        Of that wonderful force
By which the good little mother wove
Her babies' cradle with threads of love?
Why the eggs are laid by the little wife?
How the sunlight laughs them into life?
Where the shadows are deep, and the sunshine rare
Tenderly kisses the maiden hair,
Beneath the Jack-in-the-pulpit rest
The mysteries of the spider's nest.

About the middle of May, the same spring, I watched the egress of a whole colony of the young of Epeira insularis from a cocoon which I had hung upon an ampelopsis vine outside my study window. They moved with great celerity and soon were widely scattered over the vine. All mounted upwards, not a single one descending below the site of the cocoon; which habit, as I have observed, is quite common to all species. A few days thereafter their tiny filaments could be traced stretched from leaf to leaf over a large surface of the vine, as high as ten and a half feet from the ground. But not a single web was afterwards formed during the whole summer and autumn, and, as far as I know, every individual perished. Those who are familiar with like facts will readily perceive the necessity for the immense fecundity of female spiders in the production of eggs. Only under favorable circumstances can considerable numbers of any single colony reach maturity. My observations on colonies of Epeira labyrinthea and Epeira triaranea show that twenty, thirty, or fifty may survive for a short period, and construct in the same vicinity their little orbicular snares. But these, too, soon perish under the combined assaults of their natural enemies and unfavorable weather. It is probable, indeed I believe that it is quite certain, when cocoons are located in specially favored spots, and the young inhabitants issue forth under specially favored circumstances, that the majority of them pass beyond the period of babyhood and attain middle growth, and reach in goodly proportion mature life; but these examples must be comparatively rare.

Tendency to Mount Upward.

Mortality Among Spiderlings.

VI.

My observations of the habits of spiderlings immediately after egress are confirmed by such brief notes as other observers have made in natural site. Emerton says (speaking apparently from observation) that a brood of young Epeiras may often be seen living in a common web, and looking like a ball of wool in the top of a bush; while below them, connected by threads to their roost, are the skins left at their second moult, and further down, also connected by threads, the cocoon.[1] I have often seen the young of Theridium tepidariorum, and of the long legged cellar spider, Pholcus phalangioides, hanging in these cottony clusters at the top of the maternal snare, the mother herself suspended beneath. The Orbweavers thus appear to agree in this habit with these Lineweavers. Wilder also has a brief reference in the same direction to the young of Nephila plumipes, which, he says, even after leaving the cocoon, are more or less gregarious, always keeping in companies, and preserving good order while moving.[2]

Other Observers.

[1] Structure and Habits, page 110.

[2] Proceed. Amer. Acad. Arts and Sciences, VII., 1865, page 56.

FIG. 252. Assembly of young spiders, just after escape from cocoon, balled beneath a rose bush leaf.

The young of Epeira diademata, as observed in Europe,[1] have a like habit. In the spring, when the spiders are newly hatched, almost as soon as they leave the eggs they spin a small irregular mass of almost invisible lines, in the middle of which they cluster together, forming themselves into a ball about the size of a cherry stone.[2] This hangs apparently in midair, and an observer approaching it to discover its nature touches some one of the slender lines by which it is suspended, or some twig near enough to communicate motion to them. In an instant a hundred living atoms begin to disperse, the solid little ball seeming for a moment to be turning into smoke, so minute are the animals, so rapid are their motions, and so invisible the means of their dispersion. After a few seconds, if the disturbance be not repeated, the little creatures begin to subside again into a cluster, which is not at once restored to its former small size, since a thousand legs, however minute, require a little time for the necessary curling, packing, and settling by which this animate sphere of snugging spiderlings is formed.

English Epeira diademata.

A series of careful observations, made and communicated to me by Mrs. Treat, confirm the above records and furnish some interesting details. Females of Epeira harrisonæ[3] were brought from New Hampshire to Vineland in October, and there made their cocoons in the same month. These the mothers fastened to the ceiling after the fashion of the Domicile spider, and as long as life lasted manifested an unvarying love and care for the future offspring. As soon as a cocoon was completed the mother addressed herself to protecting it from insect foes and frost. For this purpose she scraped weather beaten boards with her mandibles, and made little pellets of the gray chippings, with which she covered the cocoon, which thus resembled somewhat a natural inequality in the wood.

The Harrison Spider.

The younglings did not leave the cocoon until the following spring. When they first came out they moved about six inches distant and formed a compact mass like a miniature swarm of bees, in which condition they remained a day or two. Finally, the mass broke up and formed four groups, in which they remained another day. Then they separated, and the united spinning labors of the entire brood made a thick web five or six inches in length and breadth. Herein they left their first baby clothes strung thickly along the innumerable lines. Thereafter they began to disperse, scattering everywhere around the house, each spinning a perfect little orb not much larger than a silver dollar. At this stage the observer began to look upon her spiderling emigrants with dismay. Several hundred must have emerged from each cocoon; and,

[1] Staveley, British Spiders, page 239.

[2] There must be a mistake here as to size; the clusters of Diademata would surely be much larger. [3] Epeira cinerea Emerton.

besides, a number of half grown specimens brought from New England with the colony, would be mothers in the fall. Thus, with the actual and prospective issue, an aranead invasion seemed imminent, carrying therewith the prospect that house, vineyard, and grounds would be enswathed and shrouded in cobwebs.

Mrs. Eigenmann has informed me of like behavior on the part of the young of Epeira gemma, at San Diego, California. A number of females had been placed, about the 1st of November, in tin cans, where they deposited their large tawny brown cocoons. The cans with their enclosed cocoons were placed aside, and when opened February 5th following, an interval of three months, they contained numbers of little yellow spiders, marked with a black spot posteriorly on the abdomen. One can was put out of doors and opened. In a few hours a silken ladder of delicate lines had been made from the tip upward eighteen inches to the buds and flowers of Encelia californica growing in the garden. At the top the ladder was attached to a bud which was bent downward, and between it and the stem of the plant some filmy spider weaving served as a scaffold. Upon this the spiderlings had assembled in three separate bunches, somewhat triangular in outline, which suggested to the observer tiny bunches of very prolific grapes. Mrs. Eigenmann reinclosed the spiders within the tin, in order to ship them to me, but in the act many escaped. The rest arrived safely, and immediately upon the opening of the can issued forth and began to spin their delicate filaments.

California Spiderlings.

VII.

The brood fraternity of spiderlings, in connection with their rapidly developed tendency to spin themselves away from the home centre, leads to the accidental formation of objects that curiously resemble bridges, canopies, and tents. When they begin to move they drag after them fine filaments of silk. A hundred spiderlings, more or less, passing from point to point and back and forth by single bridge lines, and keeping close together, will not be long in laying out a series of lines and ribbons that suggest miniature roadway trestles and cables of a wire bridge.

Bridge and Tent Making.

One of the most curious miniatures of this sort which I have known was once made in my library. A package of cocoons of Zilla x-notata, sent to me from California by Mrs. Eigenmann, was laid upon a long table. One morning, upon entering the room, I found that the spiders had hatched and issued from the openings in the lid of the package, a large cylindrical fruit can. From the summit of this can, as from a bridge pier, the spiderlings had strung their lines to books and paper boxes laid upon the table, and thus formed a series of piers and abutments. They had already woven a sheeted way several inches wide, that

stretched above the middle of the table for five feet. Thence it spread upward, in diverging threads, to the window curtain, on which many of the wee adventurers hung. (Fig. 253.) I kept the bridge for several days, during which time the roadway received many additional strings, and some of the baby bridge builders spun delicate little cobwebs along the edges and among the trusses of their bridge, and, separating themselves from their fellows, set up housekeeping for themselves.

Another example shows that precisely the same habit exists among

Fig. 253. Bridge of spinningwork laid by a brood of Epeiroid spiderlings.

spiders widely separated in structure. A large specimen of Ctenus was sent to me by Prof. S. M. Scudder, who had received it from a friend. The animal had come from Central America, and had brought her cocoon with her. This was a large conical object nearly an inch in diameter, constructed like the ordinary Lycosid cocoon. The mother with her egg bag was placed in a box, and after a few days, tired of lugging her cradle, hung it to the side of the box in a hammock of loosely meshed lines. It was not long before an immense host of little Ctenids, several hundreds in number, issued from the cocoon, crawled out of an opening in the cover of the box, and distributed themselves over a large study table in my room at the Academy of Natural Sciences.

Young Citigrades.

A Cantonment and Tower.

On opening the door one morning I was surprised to find every object upon the table—books, manuscript, pamphlets, bottles, inkstand—including the box in which the mother spider was contained, literally covered with a mass of sheeted spinningwork, which lay over the tops of the objects on the table like a thin silken cloth. It showed the inequalities of those objects, thus presenting a good miniature model of the immense cantonment of a modern traveling circus company. This remarkable structure concentrated upon the tallest object on the table, a large box standing at one corner. To this

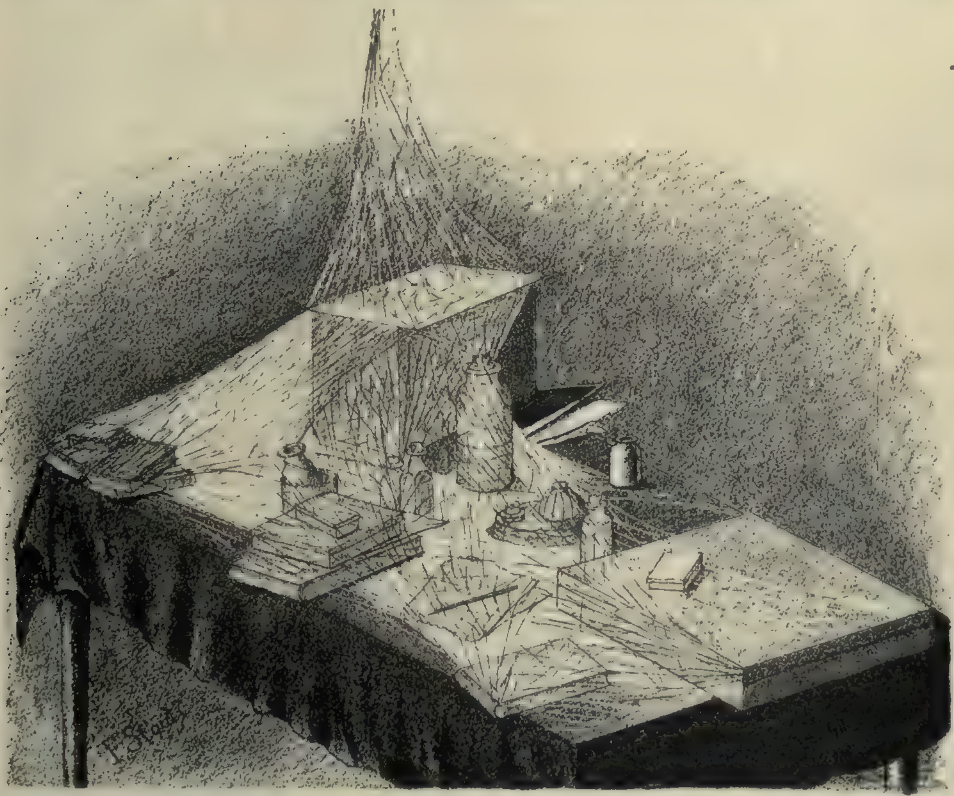


FIG. 254. Bridge lines, canopies, and turret spun by a brood of young Citigrade spiders (Ctenus).

point, evidently, the migrating brood had drifted, and here a strange sight was presented. Favored by the breeze, one adventurous spider had apparently found its output line borne upward until it caught upon the ceiling. Up it mounted, and in a little while was followed by others, each spiderling dragging after it a similar thread, until at last a tower like structure was formed, the base of which is represented in the drawing, Fig. 254, reaching entirely to the ceiling of the room, a distance of eight or ten feet. At several places along this were lines which issued towards

the window and other parts of the room, marking points where little adventurers, following their inherent tendency, had departed from their "Eiffel Tower" of spinning threads, and dispersed into other parts of the building.

VIII.

Argiope aurelia. Cocoon Life.

A valuable account of life within the cocoon of a mother Argiope is given by Frederick Pollock, Esq.[1] The cocoon, which resembles substantially that of Argiope argyraspis, contained from six hundred to one thousand bright yellow eggs glued together in the shape of a bean. The egg shells burst at the end of the fourth week. The spiders at that time were helpless and nearly transparent. At the end of the fifth week they cast off their first skin and became quite lively and active. Their color at this time was a bright yellow, with darkish legs. Their bodies were about the size of an ordinary pin head. Three or four dark spots gradually developed down each side of the abdomen. At about the end of the seventh week the spiderlings emerged through a small hole probably gnawed by them.

After departure from their cocoon their habits, as reported by Mr. Pollock, agree with those of young Epeiroids as heretofore described. They club harmoniously together, hanging closely packed in a ball, upheld by numerous lines attached to adjacent objects. This community life continues for ten days or a fortnight, the spiders occasionally separating themselves from their snugged or balled estate, but always reverting to it. During this time they eat nothing.

First Webs.

At the close of a fortnight this friendly condition ceases. The individuals of the brood scatter abroad, and each individual makes a round web about the size of a penny. Mr. Pollock conjectures that on account of the extreme weakness of these webs few insects are held by them, and that in consequence hundreds of spiderlings at this precarious period of their existence perish from starvation or other causes. He thinks that not more than one or two out of the entire brood survive. In this estimate of mortality he is doubtless correct as far as certain seasons are concerned. A heavy storm will destroy a whole brood. The presence of some skillful enemy will work a similar destruction, but under favorable circumstances quite a number of the brood will survive. The contingencies, however, are uncertain, and the life of baby spiders during the first few weeks of their existence hangs by an even weaker thread than that which they spin. Their little webs are strong enough to hold microscopic insects, the only kind that spiderlings could prey upon at their time of life.

Mortality Among the Young.

[1] On the History and Habits of Epeira aurelia. Annals and Magazine of Natural History, page 459.

When young Aurelia begins to construct snares it also begins to feed, to grow, and become darker. Mr. Pollock thinks that in a month or two from that time, according to the food it gets, the spiderling changes its skin. The females have nine changes after leaving the cocoon. From the first to the eighth moult these changes take place pretty regularly, under favorable circumstances, at periods increasing gradually from about fifteen to twenty-five days. For about two days preceding each change the spider seems to eat nothing, and remains motionless.

Moulting Periods.

The operation of getting out of the old skin is a strange looking performance, and is thus effected: The spider is fastened firmly, by a thread from the spinnerets, close to the under side of the web; the legs are all gathered together, and appear to be fixed to a spot close by; the body hangs downwards, the skin begins to split at the sides, and the spider, by a succession of powerful efforts, lasting about an hour, gradually draws its legs out of the old skin. When fairly freed, its former attitude is reversed, for it hangs with the end of its abdomen uppermost and its legs dangling loosely down; they are now quite soft, flexible, and semitransparent, the abdomen slender, and the spider feeble and exhausted. It can scarcely crawl or exert itself in any way. It remains stationary for about an hour, then turns its legs up, and climbs by its attaching line to the web, where it remains motionless for some forty-eight hours, after which it resumes its usual habits.

Mode of Moulting.

Should it at any time whilst young lose a limb or part of one, nothing appears to occur towards its reproduction until at least one subsequent change of skin has taken place; the new leg is not much more than half the length of the corresponding perfect part, and is of a somewhat lighter color. These stunted limbs Mr. Pollock thought of little use to the spider; and he could not notice that there was any reproduction of limbs lost after the seventh change of skin.

Lost Limbs Restored.

The moults take place regularly from the first (after leaving the cocoon) till the eighth. Then the spider is adult, and begins making cocoons, the first in a month's time, and others at periods within from about fifteen to twenty-five days apart. About a week after the fifth cocoon has been made the spider changes its skin for the last time, rests from its egg laying for about thirty days, makes five more cocoons at intervals of from fifteen to twenty-five days, and dies a week or so after making its last one.

Beginning to Cocoon.

The spots on the sides of the abdomens of young Aurelias gradually disappear, and give place to handsome markings of regular transverse bands across the abdomen of silver and orange alternating with black, a silver thorax, and transverse stripes of brown and black on the legs.[1]

[1] Ann. and Mag. Nat. Hist., 1865, pages 460, 461.

IX.

Naturalists have at various times recorded descriptions of "gregarious spiders," which have attracted especial interest by their singularity. Darwin mentions a "gregarious Epeira" found in great numbers near St. Fe Bajada, the capital of one of the provinces of La Plata. The spiders were large, of a black color, with ruby marks on their backs, and were all of one size, so that they "could not have been a few old individuals with their families."[1] The vertical webs were separated from each other by a space of about two feet, but were all attached to certain common lines of great length, that extended to all parts of the community. In this manner the tops of some large bushes were encompassed by the united nets. These gregarious habits in so typical a genus as Epeira seemed to the distinguished author to "present a singular case among insects which are so bloodthirsty and solitary that even the sexes attack each other." In point of fact Mr. Darwin had only come across a brood of Epeiroids, who, for some reason of environment, as protection from the wind, freedom from enemies, or abundance of food, or from sluggishness of nature, had kept within a comparatively limited space after egress from the cocoon. It is therefore not allowable to speak of this colony as a "community," in the ordinary sense of the word as applied to such social insects as ants, termites, bees, and wasps.

Gregarious Spiders. Darwin.

Don Felix de Azara had the same misconception, if indeed it be one. Although the family of spiders, he says, is for the most part regarded as of solitary habit, there is one in Paraguay which lives in a community to the number of more than a hundred individuals. Each spider builds a nest larger than a hat, and suspends it aloft at the canopy of a high tree or the ridge piece of a roof, in such a manner as to be a little sheltered from above. From this a great number of threads issue in all directions, into every available part. The lines, in fact, are fifty or sixty feet long, white and thick. They are traversed by other threads of great fineness, upon which are entangled winged ants and other insects, which serve as food for the community of spiders, each individual of which eats what itself had trapped. These spiders all die in autumn, but leave in their nest eggs which are hatched out the ensuing spring.[2] In both the above cases the facts are undoubtedly recorded correctly; but the inference from them can scarcely be justified.

Spider Communities. Azara.

Darwin, who briefly refers to the account of Azara, appears to be quite right in thinking the Spaniard's "community" to be of the same species as his own, although Walckenaer gives in a note the opinion that the

[1] Voyage of Beagle, Vol. III., Zoology.

[2] Voyages dans L'Amérique Meridionale. Par Don Felix de Azara. Tome Premier, page 212, 1806. Walckenaer's French edition.

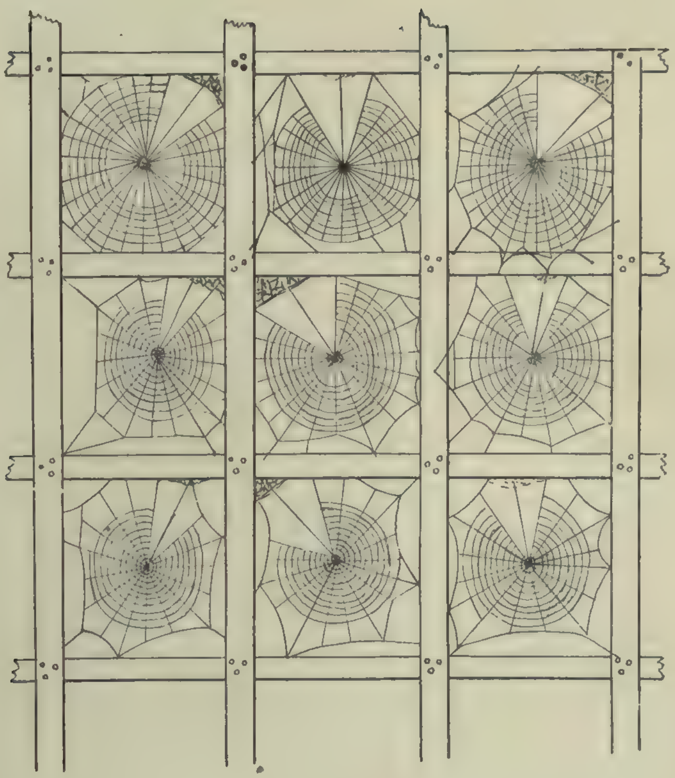


FIG. 255. A colony of young Epeira triaranea upon a lattice screen. The rudimentary nest is shown in the angles, and the orientation of the free radius illustrated.

spinningwork indicated a Lineweaver—Theridium, perhaps. Darwin, however, saw no "central nest" in which the eggs were laid; and here I think he misreads Azara, who appears to me to mean that every orbweb has a cocoon or string of cocoons attached to it, precisely as is the case with Cyclosa caudata, or hung in the retitelarian labyrinth above the orb, as is the case with the Labyrinth spider. That Darwin saw no cocoons is not strange, for his observation was made in spring ("May–June"), and as the colony was evidently a spring brood, doubtless immature, the pairing had not begun, and the eggs would not have been deposited until autumn, which in fact was the time when Azara saw them. The two accounts do not, therefore, contradict, but confirm each other. All the details of these two narratives—the number of the brood, the uniformity of the size, the distance by which the individual webs were separated, the straggling uniting threads, which were probably simply incidental to the Orbweavers' habitual behavior, and not an essential part of the snare—seem to me to justify the conclusion that these were not "communities," but simply accidental assemblages of individuals, each one of which still maintained its solitary habit. Nevertheless, one should express this opinion with some reservation in view of the possibilities of Nature.

Darwin.

The opinion here expressed is largely based on studies of broods both in artificial sites and afield. I have often found small groups of the Labyrinth spider, which have been spoken of as "colonies," occupying one bush, and presenting an appearance in kind the same as, but greatly less in degree, than the broods described by Azara and Darwin. I have seen snares of young Triaraneas hung along the strips of a latticed chicken house, in great numbers and close contiguity, more than forty of such webs appearing within a space of fifteen feet. Another similar colony appeared in the latticed screen of a cottage kitchen at Asbury Park, a section of which is given at Fig. 255. The rudimentary nests appear in the angles; and the tendency of the species, at the beginning of life, to preserve the characteristic open sector and free radius at the top of the orb, is well shown, as also the disposition to vary the location of the nest to right or left, according to convenience or whim.

Spider Colonies.

An old stone barn in the vicinity of Philadelphia has at times presented to me an appearance most interesting and beautiful, by reason of the immense number of orbwebs spread over one of the gables. Placing the face close to the wall so as to get the right reflection of light, I saw the whole surface of the building, from foundation to roof, covered with orbs as closely set as space would well allow. Along the cornice of the roof they were especially massed in manner not at all unlike the "community" of Azara. As the morning light played upon the beaded spirals and white strands, or flashed in rainbow colors from gathered dewdrops, the whole showed a natural decoration

A Tapestried Barn.

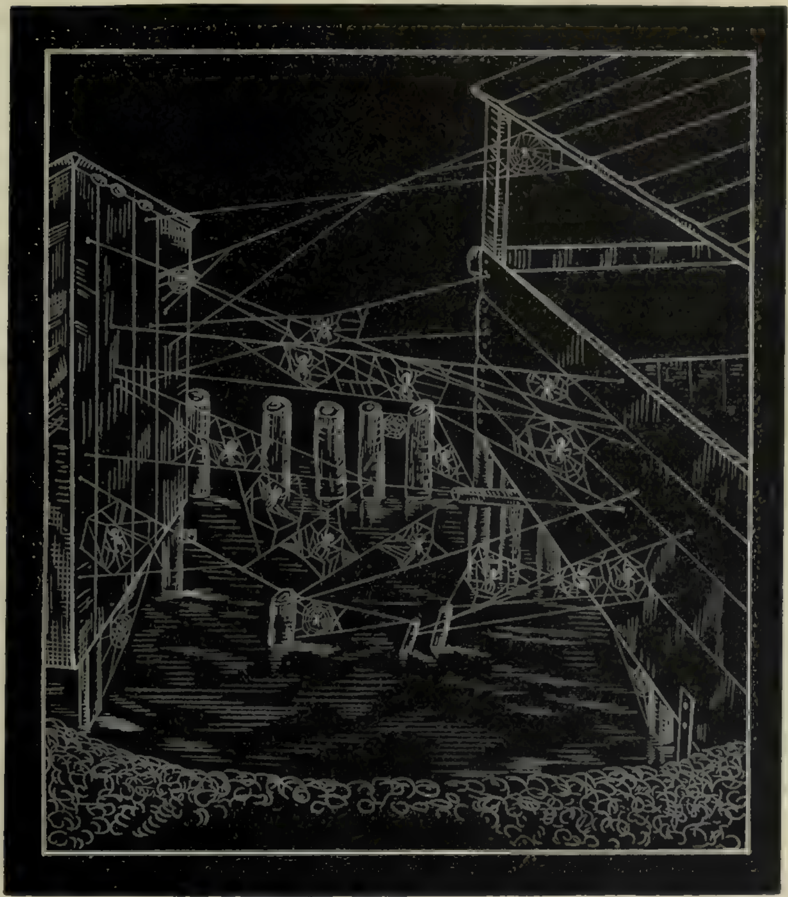


Fig. 256. A colony of Orbweaving spiders, formed on lines spun between boat houses extending into an inlet of the sea.

quite beyond the power of human art. These orbs were not all of one dimension, although multitudes did agree in size, but they were nearly all of two species, Epeira strix and Epeira triaranea, principally the former. They were undoubtedly composed of several broods of these araneads, of an equal age, who had, under favorable circumstances, been distributed in the same vicinity.[1] I may here again refer (see Vol. I., page 64) to the numerous colonies of Epeira sclopetaria which domicile within a limited area upon the surfaces of the boat houses at Atlantic City and Cape May, as another example of accidental rather than gregarious assemblage. These colonies spin their orbs between the outer walls, above the Inlet waters and hang the snares to foundation lines ten and fifteen feet long. (Fig. 256.)

Accidental Assemblage.

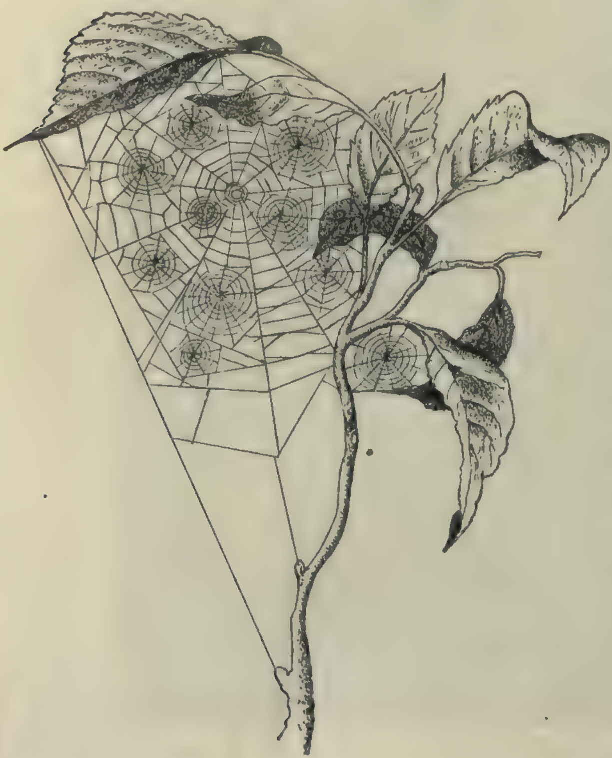


FIG. 257. Young Orbweavers nested on an adult snare.

My notes show several observations of this kind: At the summit of a tall branching weed had been woven a large orbweb, which, probably after it had been abandoned, was occupied by a group of young Epeiroids, Furrow spiders. These little settlers, with a fine acquisitiveness that suggested the once famous American theory of "squatter sovereignty," had seized upon the araneal commons, and every one appropriating to itself a corner or segment of the territory, had woven a small orbweb. These snares were pitched between the radii, which in places were cut away, and which made excellent foundation lines. (Fig. 257.) This certainly seemed a canny operation, and might have been held to savor of economy did not one know the prodigality of spiders in the matter of their spinningwork.

This use of large abandoned webs I have elsewhere seen afield and also around houses, once in a hotel outbuilding, once in a broken window of a

[1] I have observed the same phenomenon at the Fish House of the historic club in the "State of Schuylkill," on the banks of the Schuylkill River in Philadelphia.

tannery. (Fig. 258.) I had never raised the thought of a "community" to account for these groupings, for I knew that the species represented therein had the solitary habit characteristic of Orbweavers.

Another example fell under my observation, which more closely resembled those cited by Darwin and Azara. I once found on the slopes of Brush Mountain, Pennsylvania, just above the banks of the Juniata River, a large colony of the young of Uloborus plumipes. Their pretty horizontal webs were spread over the tops of a clump of low laurel bushes covering an area ten or twelve feet in diameter. It needed only increased size and more vigorous spinningwork to establish a close correspondence between the appearance of this brood's encampment and the "community" of La Plata.

Fig. 258. "Squatter sovereignty." A colony of young Epeira sclopetaria, formed upon a large orb in an open window.

A case somewhat similar to this is recorded by Vinson as observed in the African island of Réunion.[1] In the great net of the Epeiroids, stretched between trees of Pandanus, one might count the inmates living in colony (en famille), and in real harmony. There were found spiders of all ages and sizes; there were Nephila nigra and N. inaurata, messmates so hearty; and there came the Linyphiæ to establish themselves upon these huge snares in order to glean the petty prey. It is Vinson's opinion that these little aranead parasites sought the protection of the large Orbweavers by suspending themselves thereto in innumerable quantities, in order to avoid the birds and other enemies. Probably the "seeking" consists in the simple and natural fact that the young were bred in the neighborhood of the webs, and continued where they were hatched, availing themselves of the spare spaces in the webs of their gigantic kindred, precisely as the little Furrow spiders of our figures. (Figs. 257, 258.) The Linyphias, however, apparently presented a case of real nest parasitism.

X.

Thus far our observations upon the habits of young spiders have been chiefly confined to the broods of Orbweavers. We turn now to consider

[1] Araneides des Isles de la Réunion, etc., pages xix., xxi.

the habits of the younglings of other tribes. We shall find that, in proportion as the general habits of the species approach one another, there is a likeness in the behavior of the young. Between Lineweavers and Orbweavers there is little difference. Their cocoons are commonly suspended within the intersecting lines that constitute the regular snare. The little ones issue from the cocoon and arrange themselves in fluffy masses, following the tendency, which has already been noted, to climb as far towards the top as they can. Here they remain for a little while undisturbed by the mother and, as far as I know, unregarded by her. Soon they spin themselves away to various convenient sites in the neighborhood, and establish housekeeping for themselves. Thus, in the case of those spiders which weave several cocoons, one brood after another will appear and disappear.

Young of Other Tribes.

Pholcus phalangioides, the "daddy longlegs" or cellar spider of our province, carries her bundle of eggs in her jaws until the little ones are ready to hatch, when she abandons them and they take their place, in accordance with the custom of other Lineweavers, at the top of the home snare.

Fig. 259. A colony of young Saltigrades, Epiblemum scenicum, under bark. (After Herman.)

It will thus be seen that the young Lineweavers reared within the limits of the maternal snare have precisely the same habit as Orbweavers, like Epeira labyrinthea, that deposit their cocoons near their orbs within a supplemental snare of retitelarian lines.

The young of Agalena nævia remain within the cocoon until they are lively little creatures covered with black hairs, apparently well able to skirmish for themselves. They then issue forth, and may be found in great multitudes upon a dewy morning hanging beneath little sheeted webs spun upon the grass, leaves, upon the roadside, and even within the furrows of newly plowed fields. They are pretty little snares when thus covered with the beaded drops of morning dew, forming beautiful objects for study under a common pocket lens.

Agalena.

Tegenaria medicinalis presents little difference from Agalena in the general habit of the young. They leave the egg nest, rapidly disperse, and spread themselves into the neighborhood and immediately construct their characteristic webs.

The tendency of young spiders of the Wandering tribes to form colonies is not very decided, as, of course, the manner in which the younglings are reared within the mother's nest until they are able to set up housekeeping for themselves precludes such special habits as we find in the assemblages of Orbweavers and Lineweavers. But when the young Saltigrades have abandoned the maternal cell, groups of them may be seen underneath a bit of bark occupying their own tiny cells, which lie

close to each other, forming thus a miniature colony. One of these settlements I have redrawn from Mr. Otto Herman's description of the Hungarian spider fâuna.[1]

XI.

The disposition of some young spiders to settle in colonies in the neighborhood of their maternal origin may well be seen in the case of the Medicinal spider. For example, in my church cellar several windows have been left undisturbed, by my directions, in order that the various species inhabiting them might have free opportunity to multiply and build in a natural way. On one window, which is represented in the accompanying cut (Fig. 260), an interesting spectacle is presented to the observer. The opening for the window is a deep one, the wall being four feet in thickness. The glass opens into an area excavated from the embankment outside, and through which light falls, dimly illuminating the window space. The whole place is occupied by spiders of several species.

A Cellar Colony.

In the forefront may be seen the web of intersecting lines spun by Theridium serpentinum. The mother has disappeared, but her eight cocoons of flossy white silk still (in midwinter) hang in the midst of the maze of crossed lines, almost as spotless as when spun, appearing to have little capacity to gather the dust and muck of the cellar. Just beyond, and almost filling the capacious opening, the long cables of Theridium tepidariorum are stretched. Here the mother had her home, and she has left a dozen of her pear shaped, yellowish brown egg bags within the meshes of the snare. Beneath this a species of Linyphia has stretched her sheet like web, and as late as Christmas (1889) was found hanging beneath it, apparently patiently waiting to pick up such chance prey as the late season might bring her. Small snares of young individuals of the two species of Theridium above mentioned are woven at various points in the intervals. In a few the proprietors may be seen hanging back downward; from others the spinners have disappeared into various crevices and rugosities of the rough plastered window.

Further on we reach the glass window frames close against the area. In either corner, and occupying the angle for a considerable distance on either side, are stretched the triangular shaped webs of Tegenaria medicinalis. Some of them are quite large. All are covered with cellar dust and soot. Some of them look broken and abandoned. In others, if one follows the snare to the angle and runs his finger into the turret, he will find still living the sombre colored spider that wove the web. These webs and towers are or were the snares and homes

Medicinal Spider.

[1] Wohnungscolonie von Epiblemum scenicum unter Rinden. Magyarország Pók-faúja (Hungarian Spider Fauna), Vol. I., irta Herman Otto, pl. iii., Fig. 64.

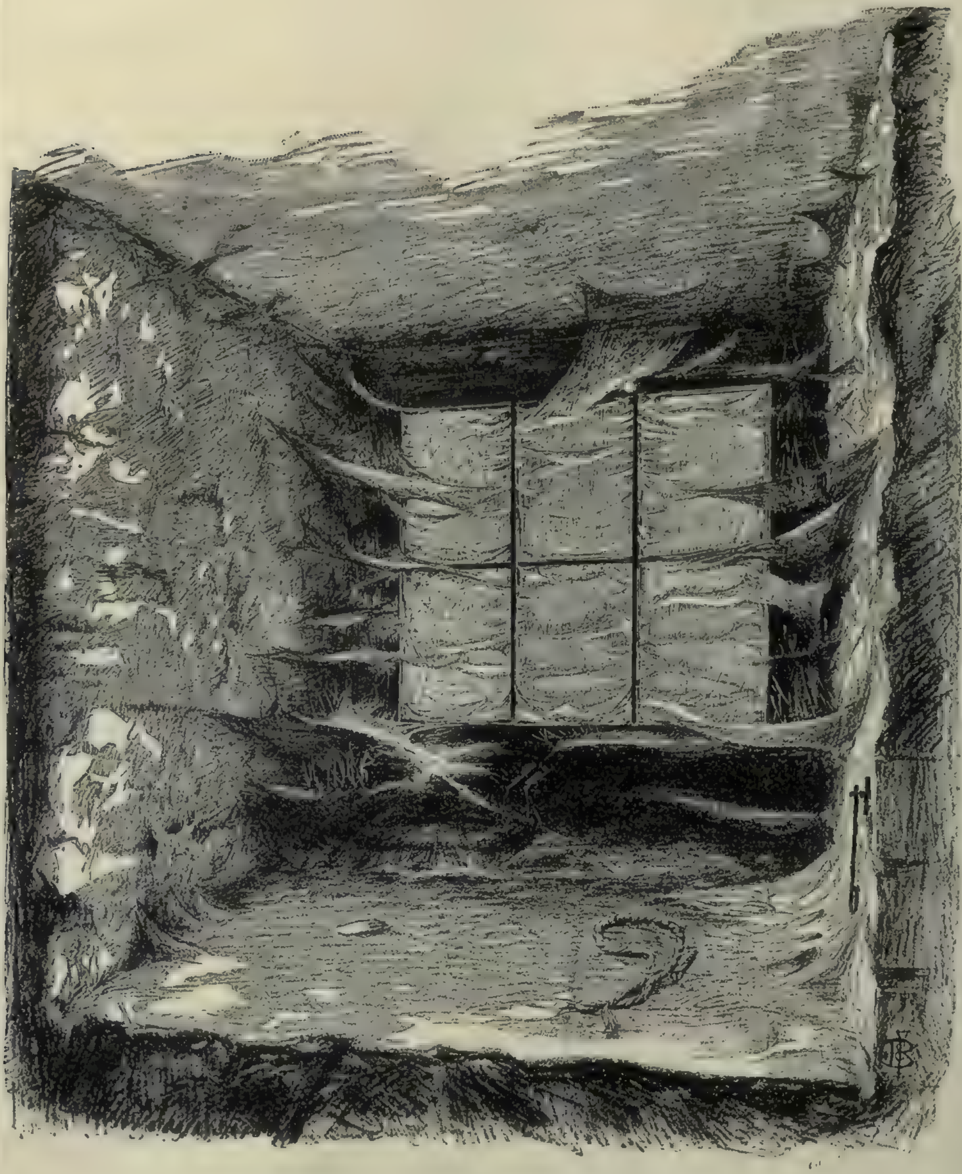


FIG. 260. A colony of Medicinal spiders, old and young, domiciled in a cellar window.

of the adult species, both male and female. Between these larger webs, occupying the angles and spread along the window frames, one sees many smaller webs. They occupy the angles where the intersecting frames of the sash cross one another. They are built just underneath the frames. They are stretched from the top of the frame to the surface of the glass, and some of them are woven upon the glass itself. They are small as compared with the webs of the adults, and they are of a bright bluish or lead colored silk, which has not been defiled by dust.

I counted on this window as many as one hundred and six of these little tents, and in the neighborhood many spiderlings may be found. But many more have disappeared. Whither have they gone? Alas, there can be no doubt that many of them have fallen victims of that fratricidal strife which is sure to appear when the young of any brood of spiderlings have once set up housekeeping for themselves. Others, doubtless, have gone to satisfy the appetite of their own mothers, who, when once their broodlings have left the maternal care, make no distinction between their own and another mother's offspring, but eat all indiscriminately that fall within their maws, while on still others alien species have preyed.

A Camp of Juveniles.

The window presents an interesting object as it is thus depicted, and the carefully made photograph, which has assisted the artist's study, accurately presents to the reader what may be seen by the student who takes his stand with the author and looks into this window. Elsewhere throughout the cellar the same phenomenon is presented. On another window I counted fifty-three of these youngling snares spread in like positions; but the one here figured is the most interesting object, and presents the largest exhibit I have seen of youthful spider industry intermingled on a natural site with the webs of adults and of other species.

Young Water Spiders.

The Swedish naturalist Clerck saw many little Argyronetas swimming in the month of July,[1] which indicates that they are hatched about that time, and appeared greatly to enjoy themselves in sporting through the element which forms the environment of their home. The instinct of swimming is as fully developed in these little ones at the very outset of life as in their parents.

Swimming Excursions.

According to De Lignac,[2] when the mothers of Argyroneta aquatica are about to oviposit they construct a new silken bell or renew that which they have already made. The eggs are enclosed therein, and when hatched one may see issuing from the beautiful balloon, which is shining white, a prodigious quantity of little bubbles, brilliant as quicksilver, which swim about in different ways! These are the young water spiders. One female, observed and reported by this author made her cocoon on the 15th of April, and on the 3d of

[1] Aran. Svecici, pages 149, 150. [2] Op. cit., page 53.

June following the little spiderlings issued forth. Their excursion was not simply for observation. They mounted in search of air. Many made little cells of their own upon a water plant which they found in the vase; nevertheless, they still continued to go into and out of the maternal mansion. Some of them threw themselves upon the corpse of a dragon fly larva, each one tugging at his own side in such a way that they tore the body as ferociously as two dogs engaged in dragging at a piece of flesh.

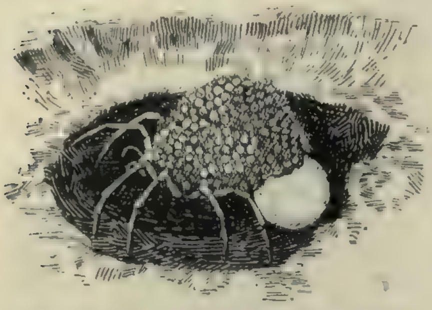


Fig. 261. Lycosid mother, with her newly hatched brood upon her back.

On the fifteenth day they changed their skin, and our observer saw a large number of their moults floating upon the surface of the water. After the young spiders had left the maternal cell it appeared transparent; but two days after the advent of the family a part appeared to be renewed, satiny, and opaque. When the balloon was deserted, the male, who had constructed a beautiful cell upon the surface of the water, sometimes came to visit the old apartment. These spiders have a local attachment for the neighborhood of their cells.

XII.

The Lycosid mother referred to (page 143) presented a good opportunity to observe the habits of her younglings. One month after her cocoon had been made, June 4th, the spider was found with the young hatched and massed upon her body, from caput to abdomen. The empty egg sac still clung to her spinnerets, and the younglings were grouped upon the upper part of the same. The abdomens of the little spiders were of a light yellow color, the legs of a greenish brown or slate color, and the brood were tightly packed upon and around each other, the lower layers apparently holding on to the mother's body and the upper upon those beneath it. Twenty-four hours thereafter the cocoon was dropped, and the spiderlings clung to the mother alone. An examination of the cocoon showed that the young had escaped from the thin seam or joint formed by the union of the egg cover and the circular cushion when the whole was pulled up at the circumference into globular shape.

Spiderlings Pick-a-back.

Fig. 262. The site of a brood of Dolomedes between a boat landing and the piles.

On June 11th, one week after the hatching of the young Lycosids, one hundred had abandoned the maternal perch and were dispersed over the inner surface of the jar and upon a series of lines stretched from side to side. About half as many more remained upon the mother's back, but by the 13th, two days thereafter, all had dismounted. In the meantime they had increased in size at least half, apparently without food.[1]

Young Dolomedes.

One summer, at the steamboat landing of Lake Saratoga, New York, between the platform and the logs driven as piles to protect it, I observed a large nest of interlacing lines within which hung a round cocoon from half to three-fourths of an inch in diameter. Immediately beneath the cocoon many young spiders were massed in colony, hanging inverted, in the usual posture, from the crossed lines of the maze. These were the little fellows who had been hatched within the swinging egg bag, and who had doubtless issued therefrom within the last week or ten days. At least, they were so well grown that they might have been of that age.

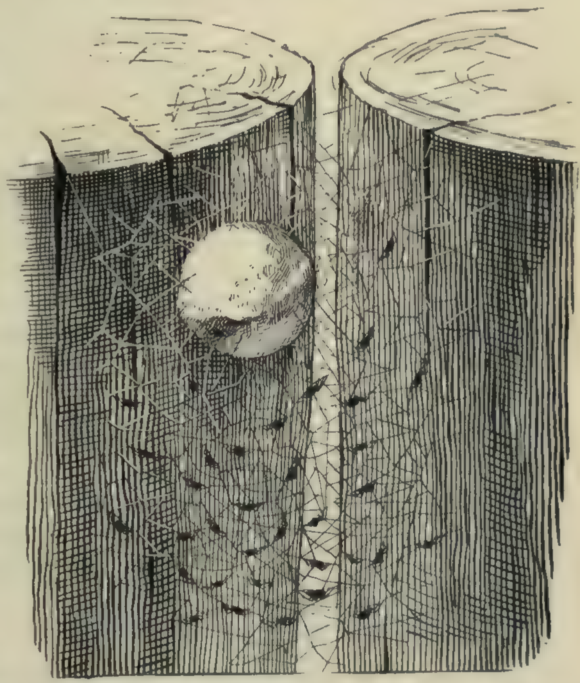


Fig. 263. View of Dolomede cocoon in site, and part of the brood hanging to the supporting lines.

The cocoon was so evidently of the Lycosid character that I was for a moment perplexed to find it in such a position. But, remembering the habit of Dolomedes, I inferred that this may have been the cocoon nest of one of the large Dolomede spiders that frequent the borders of our American lakes and other waters. I captured some of the young spiders, with some difficulty however, for they were old and active enough to scamper away upon the least agitation of the snare. An examination showed that they were young Dolomedes, probably Dolomedes tenebrosus, a spider that attains great size under favorable circumstances. No doubt, the mother had carried her cocoon along the shore, hiding among rocks or underneath the platform of the boat landing, until Nature prompted her to the last action characteristic of her

[1] Proceedings Acad. Nat. Sci., Phila., 1884, page 138, "How Lycosa fabricates her round cocoon."

species. Thereupon she swung it within a tented maze as described and figured, and probably set herself to watch in some convenient position. She, however, had disappeared when the naturalist came upon the scene, and may have perished or returned to her life occupation of capturing insects upon the blue waters of Lake Saratoga. Fig. 262 shows the position of the snare and cocoon in site, and Fig. 263 shows the snare enlarged, with the cocoon about natural size, and the young clustered beneath.

When one approaches the cocooning nest of Pucetia aurora he usually sees the mother hovering over her offspring, or starting a new sac of eggs.

Pucetia aurora.

She makes two and sometimes three cocoons on one twig. Sometimes the young ones will still be within an old cocoon while the mother is enclosing a new bundle of eggs immediately adjoining the old one. The young were not seen upon the mother's body by Mr. Wright, who forwarded the specimens to me from California. The mother stays close by her cocoon nest. If the spiderlings be hatched out, she will perhaps drop down a foot or more. If the first effort to capture her be not successful, she will not drop to the ground unless forced to do so. If engaged in carrying her cocoons, it requires force to separate her from them. (See Chapter V., page 147, and Fig. 180.)

The young ones take alarm sooner than their mother. They drop down a few inches from their perch on the maze of intersecting lines surrounding the cocoon, or, at times, as far as two feet, each one suspended to a tiny thread, forming thus a pretty swinging fringe to the overhanging nest. In a few moments, if no further alarm be created, the younglings reascend by their traplines to their perch, but, if they be frightened again, will drop entirely to the ground and run into concealment. In such cases the little ones were not observed to jump, as is the habit with the mother.

The young of Lycosids generally escape from their cocoons through the seam which extends around the central part. It is thinner at this

Turret Spider.

point and splits nearly around the whole circumference, so that the young come out in a body. But with the Turret spider, Lycosa arenicola, the young cut a smooth, round hole in the cocoon just large enough for them to come out one by one. The first three weeks the little objects are piled all over the head and thorax of the mother, often completely blinding her. They seem ambitious to reach the highest point, and jostle and crowd one another in various efforts to be at the head of the heap. The mother patiently endures this for a time, but when her younglings become too thick over her eyes, she takes her long fore legs, which she uses as feelers or hands, reaches up and scrapes off an armful and holds them straight in front of her. Soon she gently releases them, slowly opening her arms, and they quietly take their places around the edge of the tower, where they usually remain until the mother goes below, when they all follow. Upon her reappearance they are again stationed upon her back.

The young do not all leave the mother at the same time, but go out in detachments, when about three weeks old. When three or four weeks old the mother manifests a disposition to send them adrift. She is no longer quiet and patient, but frequently picks up one of her babies and throws it across the jar, yet seems to be careful not to injure it. She behaves much in the same way that the higher animals do in weaning their young.

Leaving Home.

When the spiderlings leave the mother's back they run up a tree or some neighboring plant and are lost to sight. Some linger with the mother until the cold weather begins. The mother clears the ragged webs and moults from her body and looks plump and bright. She sits on the top of her tower with the remaining little ones stationed around the edge. They now seldom rest upon her, and when she goes within her burrow they all follow. Upon her reappearance a few spiderlings, it was observed, had availed themselves of the opportunity of being carried up upon her back, but they did not remain there.

One of this brood was observed making a small burrow in the jar in which it was confined. The tube was less than one-fourth inch in diameter, and the spiderling was two days in excavating an inch below the surface. On the top of this burrow it built up a tiny tower fully half an inch high, which was made wholly of earth intermingled with web. In digging, the diminutive architect brought the little pellets in its mandibles, and those which it did not wish to use in the tower it let fall by the side. It did not shoot the earth to a distance as the adult Turret spider does, but stood on the top of its tower, opened its mandibles, and let the pellet drop. At the same time it threw apart its legs as if that would help it to dispose of the earth, a movement which Mrs. Treat speaks of as being very baby like.

Turret Building.

The actions of this little Turret builder showed emphatically that she had shut herself apart from the rest of the family and would not be annoyed by them. Frequently one of her brothers or sisters, meandering about, came to its little tower, and not often would one pass by without going up and looking in. This always seemed to exasperate the small householder. She dropped her work, sprang from the top of her tower, and sometimes chased the fleeing brother half across the jar, then turned and went back to her work. No such disposition was manifested, as far as Mrs. Treat observed, as long as the younglings remained with the mother. During that period they crowd together, walk over each other, and never have any quarrels.

At the end of the sixth week after birth most of the brood, if permitted, would abandon the maternal nest and build tubes and towers for themselves. Two had erected their towers within two inches of one another, and they sat on the tops of their turrets, often facing each other and watching the tiny scavenger beetles that bred in the jar and lived on the refuse insects thrown out by the mother.

Catching Prey.

These beetles were food for the young housekeepers, but Mrs. Treat thought that they were not to their taste as much as flies, although they dared not as yet take a living house fly, and if one came near them they quickly dodged within their burrows. If a fly were killed and laid on the tower, however, they would try to take it within, but it being impossible to do this with the wings and legs adhering, they made many ingenious but futile attempts to get the large carcass inside the burrow. If the wings and legs were removed from the insect, and laid upon the tower, the carcass was soon carried below and after a few hours was brought up to dry and thrown out.[1]

Lycosa tigrina.

In November the Tiger spiders all hermetically close their doors and keep them shut until the following April, when they again come forth, the females each with a cocoon of eggs attached to the spinnerets. The eggs hatch in May, and the young spiders crawl upon the mother's back, literally covering her body. After a few days they leave her, and all at once come rushing out of the burrow. For two or three months these young spiders flit about here and there over bushes and on the lower branches of trees, seemingly ambitious to get to higher places.

Toward the end of July their roving lives cease, and they settle down and dig little burrows in the earth, which they do not conceal the first season. The wasps do not molest the young ones. The following spring, when a year old, they are little more than half grown, and during the summer they grow rapidly and moult several times, each time changing their appearance. By August they seem to be nearly full grown, when their enemy, the wasp, makes havoc among them. By thus tracing the life history of this spider we find it to be two years old before the first brood of young are hatched, and, if no accident befalls it, it probably lives several years.[2]

XIII.

Young Atypinæ.

Mr. Frederick Enock [3] determined the manner in which the young of Atypus piceus issue from the parental nest, and their subsequent behavior. October 15th he dug up five tubes, each containing a male and female. The males were removed, and the tubes containing the impregnated females were reset in a bank at the bottom of a garden, and were kept under daily notice during the seasons following. March 28th of the next year the aerial extensions of the tubes, which during the winter had laid nearly flat upon the bank, showed signs of being repaired by the inmates. On the next day in the apex of each of the five tubes there was observed a small round hole one-sixteenth of an inch

[1] Mrs. Mary Treat, "Home Studies in Nature," Harper's Magazine, May, 1880.
[2] Idem, page 712. [3] Trans. Ento. Soc. Lond., 1885, page 395.

in diameter. The succeeding day, March 30th, was warm, and at ten o'clock morning a young Atypus was observed to emerge from one of these holes. It was shortly followed by others, until ten had left the home of their birth never more to return. A few younglings also issued from two others of the tubes.

The first young Atypus that emerged walked a short distance to the foot of a grass stem, up which it crawled, leaving its silken thread as it went along. When it had climbed about an inch high another young one came out, took hold of the first line, adding its thread to it; and so on, each successive youngling following the leader, which, by the time the tenth one emerged, had mounted up several inches. As the leader climbed from stem to stem it bridged over the intervening space with the never ending silken cord, along which each successive spiderling followed, strengthening it as they passed, until it became quite visible, glistening in the sun.

"Follow the Leader."

The spiderlings above alluded to kept mounting up higher and higher, and ascended to the top of a number of pea vine sticks which had been planted in the neighborhood, and were about three feet and a half above the ground. The first adventurer, having arrived at the top of one of these sticks, walked around and around it. The others soon joined the first, and none seemed inclined to descend by the way the party mounted. The rising wind gently swayed the sticks about, until some of the spiders were blown off into midair, but still keeping hold upon their endless silken cord until they became attached to other sticks. These they mounted as they did the first; but were again and finally carried off by the breeze at five o'clock afternoon, and landed upon the ground, where they hid themselves among the grass and rubbish, no doubt taking lodgings therein for the night, during which there was a sharp frost.

The next morning all the small outlets of the tubes were carefully spun up, and, judging by the character of the web, Mr. Enock thought that the mothers had closed the openings to prevent the remaining members of the family leaving the parental nest until more favorable weather would permit them to do so with safety.

The above behavior appears to represent accurately the ordinary habit of the spiderling Atypus immediately after exode. That is to say, it first seeks a position at the summit of any neighboring plants or elevated objects, from which it is carried away by the wind upon an aeronautic expedition of greater or less extent. Falling upon the earth, it conceals itself for a little while, and then proceeds to dig in the sand or soil a tube which is extremely minute, corresponding in size to the spider digging it. As the spiderling grows it enlarges its tube, or, removing from the one in which its child life was passed, prepares another nest better adapted to its mature condition.

First After Exode Habits.

In these particulars the young of Atypus differ little, perhaps, I may say, not at all, from the habits of Lycosids, after they have left their mother's back and started housekeeping for themselves. Indeed, the resemblance has a wider range among the tribes, inasmuch as Orbweavers, Laterigrades, and Saltigrades show the same disposition to seek elevated objects immediately after exode, and thence procure dispersion by means of the wind.

The mother Atypus may occasionally carry its young upon its back during residence within the parental nest, but has not been seen doing this outside of its cave. This fact is not strange, since it rarely leaves its tube at all, but spends its entire life within its silken domicile, which is for it alike home, snare, nursery, and grave. According to Mr. Enock, maturity is not reached until the Atypus is at least four years old.

The young of Atypus piceus were seen by Mr. Enock, September 25th, in the same nest with the female, looking very white and moving feebly, as evidently just hatched. He found the young nested with the mother at various dates through September, October, November, and again in March and April of the year following. It is thus established that after the young leave the cocoon in August and September, they remain with their mother during the entire autumn and winter, and during the early spring until the weather is mild enough to justify their leaving the maternal home and establishing nests of their own.

Nurture in the Nest.

What they feed upon during this period is not known. Much of the time, no doubt, they are in a torpid condition, requiring no food. There is not the slightest evidence that they prey upon one another. It is possible that the mother may provide food for them, and, indeed, this is highly probable. If so, these troglodyte spiders furnish a beautiful example of domesticity; and the maternal care shown by creatures so unprepossessing in personal appearance and occupants of such gloomy homes, is not excelled by that of any of the known lower animals. I might, perhaps, truthfully add that the more highly organized vertebrates scarcely exhibit a greater amount of maternal tenderness and care.

Young Tarantulas.

The immense cocoon of Mygale, sometimes as large as a hen's egg, is stocked with as many as two thousand eggs. In Cayenne the little Mygalidæ, when issuing from the cocoon, are attacked and devoured by red ants, and are too feeble to offer effectual resistance. Walckenaer describes the contents of a cocoon of Mygale avicularia from Cayenne, which was infested by a multitude of parasitic Cynips. Numbers of young spiders were found therein. They were about two lines long, of uniform yellowish white color, except at the eye space, which was brown. The long spinnerets showed at the apex of the abdomen. The mandibles were prominent and curved, the eyes very apparent. All the characteristics of the genus were well developed.

The inner intermediate eyes were large and of a reddish brown. The first pair of legs were longer than the fourth pair.[1]

It is a suggestive fact in the natural history of these immense representatives of a race so destructive to insect life to find them the victims of such puny creatures as parasitic Ichneumon flies and Cynips, and to see their young devoured in multitudes as a delicate morsel by little red ants. It is thus that Dame Nature knows how to keep an equilibrium in the thronging life of the insect world, and, moreover, to bring it about by what seems an apt and admirable stroke of justice well in accordance with "the eternal fitness of things."

XIV.

Making a Trapdoor.

Mr. Moggridge was fortunate enough to see the female of Nemesia meredionalis constructing a trapdoor in captivity, after having been placed in a flower pot full of earth, in which a cylindrical hole had been made in order to forward the spider's operations. She quickly disappeared into this hole, and during the night following made a thin web over the aperture, into which she wove any materials that came to hand. At this stage the trapdoor resembled a rudely constructed horizontal orbweb, attached by two or three threads to the earth at the mouth of the hole. In this web were caught bits of earth, moss, leaves, etc., which the spider had thrown into it from above. On the second night the door was nearly the normal texture and thickness, but in no case would it open completely. Mr. Moggridge believed that when a door is fastened, the few threads which serve as supports and connect it with the earth on either side, are severed.

Young Trapdoor spiders, both of the cork and wafer kind, when taken from the nest of the mother, will make their own perfect little dwelling in captivity, and Moggridge observed them construct tube and door within fifteen hours. This may be favorably compared with the work of the adult Cteniza moggridgii, which the same observer saw make a perfect tube and furnish it with a movable door in a single night when confined under gauze or moist earth.[2]

Young Builders.

The same author has enabled us to decide that the young Nemesia proceeds in precisely the same manner as the adult when it builds a nest. While engaged at night in sketching, he detected something moving at the mouth of a tiny hole just large enough to admit a quill pen, in a mass of earth near where he sat. The lamplight fell full upon it, and he soon saw that the moving object was a very small spider, which was at work in the mouth of its tube. The opening of the tube was completely uncovered, and it soon became apparent that the little aranead was intent upon remedying this deficiency. After a few threads

[1] Walckenaer, Aptères, Vol. I., pages 218, 219. [2] Trapdoor Spiders, Supplement, page 243.

had been spun from side to side of the tube, he watched the spider making one or two hasty sorties, apparently spinning all the while; and finally saw her gather up an armful, as it were, of earth and lay this on the web.

After this the occupant of the tube was concealed, but the observer could see from the movement of the particles of earth that they were being consolidated, and that the weaving of the under surface of the door was being completed. Next morning he could lift up the door, which had the form of a small cup of silk, in which the earth lay. It was then soft and pliant, but in ten days' time it had hardened and become a very fair specimen of a minute door of the "cork" type.[1]

He had watched the proceedings of young spiders when taken from the mother's nest in the following species: Nemesia manderstjernæ, Nemesia eleanora, Nemesia congener, and Nemesia moggridgii, the first three constructing wafer doors and the last a thick beveled or cork door nest. All of these very young spiders will excavate their own tubes and bring out pellets of earth, which closely resemble those carried out from their galleries by ants.

The young brood while still in the mother's nest will often comprise individuals of different sizes, and, though a majority are no larger than one-fourth of an inch long, some may occasionally be found that are fully twice as large. The little nests which they make in captivity vary accordingly in size. A large number made in captivity varied in size from two lines (one-sixth inch) to three lines (one-fourth inch) in width.

These little spiders need to be kept constantly supplied with flies, which should be killed and placed near their nests. They are often so greedy that they will try to drag a house fly into their tubes, for which it is much too large, and when the door is pushed open the fly remains sticking in the entrance of the nest, with its legs up in the air. One may often feed these by approaching carefully without causing any vibration, pushing the fly, placed on the end of a pencil, within reach of the spider.[2]

Nest Development.

Mr. Moggridge entertains the opinion that, as a rule, the mature trapdoor nest with its hinged lid is the result of many successive enlargements, beginning with the diminutive tube of the baby spider, which is no bigger than a crow quill. This infantile home is not abandoned, but is enlarged from time to time according to the growth of the inhabitant, and becomes the abode of the full grown spider.

Of course, this must require a series of months, and possibly of years, for its accomplishment, and it is not unlikely, judging from what we know of the prolonged life of some of the Territelariæ of other families (for

[1] Moggridge, Trapdoor Spiders, page 119. [2] Trapdoor Spiders, Supplement, 245.

example, that of Atypus piceus, as shown by Mr. F. Enock, and that of Eurypelma hentzii, as I have demonstrated by several species), that the Trapdoor spiders may live for several years at least. Mr. Moggridge was inclined to think, judging from the character of the nest and its surroundings, that some which he saw had been occupied more than a year. Evidence of enlargement of the door is not rare to meet with, though, as a rule, the new piece is woven on to the old with such neatness as more or less to obscure these. Examples were found in which the old and smaller door of Nemesia meredionalis was partially attached to the large new door which had been constructed below it.

First and Last Doors.

This view is borne out by the fact that a cork trapdoor may be readily separated into a number of layers of silk, with more or less of earth between every one. These layers decrease in size from without inwards, and together form a sort of saucer in which the small central mass of earth lies. (See Fig. 264.)[1] By moistening a series of the cork trapdoors of Nemesia cementaria, Moggridge was able to detach, in one of medium size, from six to fourteen circular patches of silk, of which the outermost, or that which forms the lower surface of the door, was the largest, and the innermost the smallest, thus being intermediate in size as in position. The last and smallest appears to be the first door the spider ever made, and the consecutive layers mark successive stages in the enlargement of the nest. Baron Walckenaer found more than thirty alternate layers of silk and earth in the nest of Cteniza fodiens.[2]

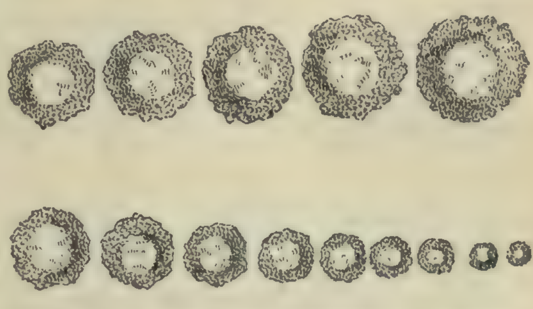


Fig. 264. Successive layers in formation of a trapdoor. (After Moggridge.)

Moggridge was confirmed in his opinion that these layers mark a successive enlargement of the nest, by the additional fact that in very small doors they are few or single, and a proportion is observable between the size of the door and the number of layers of which it is composed.[3]

In order to test whether the doors were enlarged or not, Moggridge measured the surface doors of seven double door nests, and one minute cork door, on April 30th. On the 8th of October following he measured all these nests once more and found that they all were enlarged, the average rate of increase being one and seven-tenths lines in the five and one-half months which had elapsed. The highest increase of the eight was from five lines across to seven and one-half lines across. In none of the

[1] After Moggridge, pl. xiv., and page 193. [2] Apt., Vol. I., page 228.

[3] Trapdoor Spiders, page 125, and table from twenty-eight specimens examined, page 150.

series had the increase been less than one line in width, which was equal to an increase of one-fourth the original width of the door.

We can scarcely venture from such limited premises to draw any precise conclusions. But if we suppose that during the entire course the nests increased on an average by about four lines in diameter, and assume that the rate of growth continues the same, the nest of the infant spider, whose surface door measures scarcely a line across, would still require four years to attain the dimensions of some of the largest double doors, whose surface doors measure ten lines across.[1]

Grecian and Italian Species.

In the nests of several females of Cteniza ariana Walck., on the island of Niros, in the Grecian Archipelago, Mr. Erber found eggs at the bottom of the tube attached by separate threads, and not placed in cocoons. The young spiders when hatched were turned out from the asylum of their mother's nest, and these creatures were found, scarcely two lines long, already established in nests three inches deep and furnished with perfect trapdoors, specimens of which were collected.[2]

Costa states that the young of Nemesia meredionalis, observed by him in the neighborhood of Naples, remain in the bottom of the maternal tube. The mother herself stands at the door, holding the lid raised by means of the four anterior feet and the palpi, the curved extremities of which she inserts between the rim of the tube and the door. Sometimes the limbs do not appear, but the spider leaves only a chink for observation. He also observed the fact that the young spiders make perfect little tubes entirely independent of the maternal nest.[3]

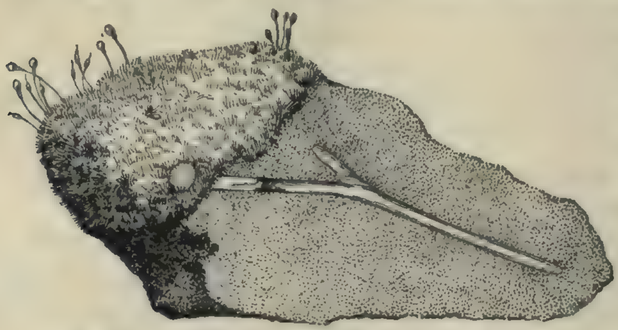


FIG. 265. The trapdoor and burrow of a young Nemesia meredionalis. Natural size. (After Moggridge.)

XV.

Marvels of Instinct.

Most persons who consider the above facts will cordially join with Mr. Moggridge in thinking that these very small trapdoor nests, built as they are by minute spiders probably not very long hatched from the eggs, must rank among the most marvelous structures of the kind with which we are acquainted. That so young and weak a creature should be able to excavate a tube in the earth many

[1] Moggridge, Trapdoor Spiders, page 127.
[2] Verhand. der k. k. Zoologish-botanischer Verein in Wien, Vol. XVIII. (1868), page 905.
[3] Costa, Fauna del Regno di Napoli, Aracnidi (1861), page 14, tab. i., Figs. 1–4.

times its own length, and know how to make a perfect miniature of the nests of its parents, seems to be a fact which has scarcely a parallel in Nature. (See Fig. 265.)

When we remember how difficult a thing it is for even a trained draughtsman to reduce by eye a complicated drawing or model to a greatly diminished scale, we must own that the performance of this feat by a baby spider is so surprising as almost to exceed belief. And yet even the most complicated form of trapdoor nest, namely, that of the branched double door type, is perfectly reproduced in miniature by these tiny architects, with the upper door, the lower door, the main tube, and the branched body accurately placed.[1]

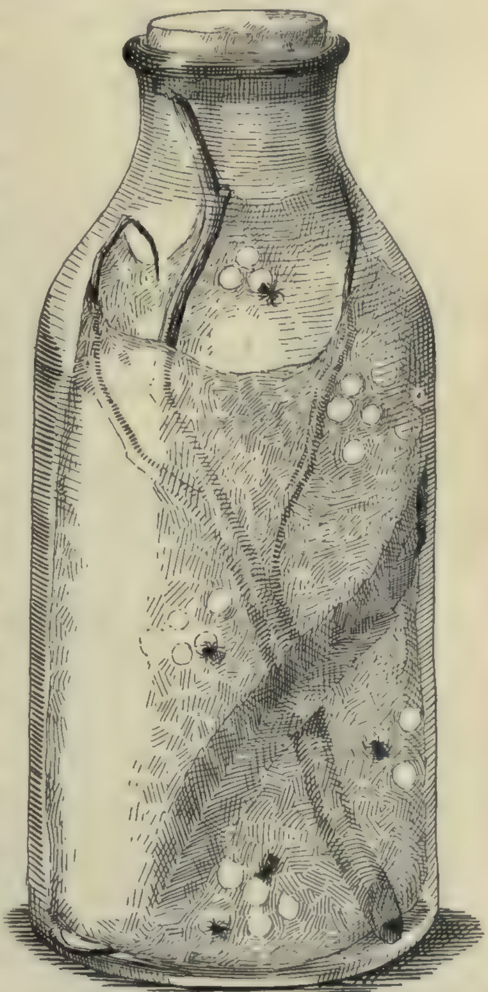


FIG. 266. The spinningwork commons of a brood of young Agalenas, made in confinement.

Mr. A. R. Wallace shows that there is some reason to doubt whether birds, which are so frequently said to build by instinct, would construct the nest proper to their kind if they were separated from the mother at the earliest age and reared apart from her or others of her kind. He states that birds brought up from the egg in cages do not build the proper specific nest; nor do they even sing their parent's song without being taught.[2] Whatever may be the case with birds or other highly organized animals, there is not the slightest reason to doubt that, with spiders, all forms of nests are built in the most perfect condition by the young as soon as they are able to do any work at all after being hatched from the eggs. There is no fact which I have more frequently observed and demonstrated than that all the interesting habits of spiders, including those which would appear to require the greatest reasoning powers, or the exercise of faculties that in highly organized animals would imply the possession of experience and cunning

[1] Trapdoor Spiders, page 127. See Fig. b, plate ix., page 98.

[2] Contributions to the Theory of Natural Selection.

skill, are exercised in their utmost plenitude by baby spiders fresh from their cocoons. A few additional illustrations may be here grouped together, although many examples are scattered throughout these pages.

Young Agalenas.

A brood of Agalena nævia hatched within a fruit jar, showed in a rather curious way the tendency of young spiders to imitate the parental snare. A leaf or two and several dry twigs had been placed within the bottle, and these formed points of support for the delicate, sheeted spinningwork which the young Agalenas were not long in spinning. Soon a hollow cylinder of silk was woven inside the jar, quite near the glass. Now, the habit of this spider in natural site is to pierce her sheeted snare with a circular opening, to which is attached a funnel like tube leading downwards into the grass. The limitations of our imprisoned spiderlings would not permit them to form such a structure; but, yielding to the tendency of inherent instinct, they penetrated the sheeted cylinder with circular holes, which, curiously, were placed in little groups at various points. (See Fig. 266.) Through these openings the spiderlings came and went, and, although they were continually adding to the texture of the sheeted common by the draglines which they carried after them, I never observed that the circular holes were closed.

Fig. 267. A young Agalena nævia.

When these little Agalenas make their exode in natural site, and have the opportunity to pursue unobstructed their natural tendency, they spin a little miniature of the maternal snare, except that, as a rule, the funnel like tube is not quite as distinctly marked, and does not form so prominent a part of the web. At the period when the Agalena broodlings are issuing from their cocoons they may be seen dispersed over all manner of surrounding surfaces, upon which they have spun their peculiar snares. They hang them between blades of grass, stretch them across the surfaces of leaves, weave them within the angles of houses and walls, in all kinds of crannies and corners, upon rocks, and boards, and logs, and bits of dry wood; and I have often observed them by scores and hundreds spun during an evening over the broken clods of a recently spaded garden patch, or along the furrows of a plowed field. These tiny sheeted nests, when seen of an autumn morning covered with the beaded drops of dew and glistening in the early sunlight, present a remarkably beautiful appearance. A sketch of one of these dew covered nests is given at Fig. 268.

M. Lucas observed on the part of certain young Trapdoor spiders, Cteniza moggridgii, a behavior somewhat resembling that of these young Agalenas, but displaying even more decidedly the specific industrial characteristics. Mr. Moggridge sent some of the Ctenizas by mail to M. Lucas, at the Jardin des Plantes in Paris, enclosed in little, wide mouthed, cylindrical glass bottles. The young Trapdoors, in transitu or shortly thereafter, lined the bottles with silk and then proceeded to close them at the

FIG. 268. Dew covered web of a young Speckled Agalena.

mouth with a door fitting accurately into a beveled lip. In the manufacture of these doors fragments of moss, the only material at the spiderling's disposal, were used in place of earth.[1]

The behavior of two of the brood of Epeira sclopetaria referred to (Vol. I., page 150), was notable as showing in its plenitude the presence of the strongest instincts immediately after egress. A small insect, while hovering around the lamp, was snared in the straggling lines. A spiderling near by instantly ran to it, threw out from its wee spinnerets jets of filaments, and completely enswathed the creature precisely in the manner of an adult.

Young Epeira.

Another of the brood began in a few minutes after its coming to make an orbweb. The foundations were attached to the end of one of the lines hanging to the lamp globe by dropping a thread to the table, a distance of eighteen inches; then a triangular frame was formed by uniting a point of this thread to the opposite end of the upper line; within this frame a perfect orb was spun. (See Fig. 141, page 151, Vol. I.) I observed the whole process, laying in the radii, spinning the notched zone, the foundation spirals, the beaded spirals; all was complete, and an exact likeness of a perfect adult web. Neither of these young spiders could have been more than half an hour out of the natal tent; nor had they any previous experience, having been excluded from all spinningwork whatsoever; nor had they taken food of any sort. There was no cannibalism within cocoon or tent before the egress of the brood, as not a single dead individual remained; every egg had hatched a perfect spider, and all the brood were gone, except three living ones, who remained within the tent until the next day. Nothing could more fully demonstrate the facts that the perfect exercise of the function of spinning, and the full possession of the characteristic habit of capturing prey, are innate with the spiderling, and dependent upon and influenced by nothing external whatsoever. These facts, indeed, I have often demonstrated in the various families and species by experiments quite as conclusive as the above.

FIG. 269. Baby Epeira swinging in a foot basket.

Characteristic Habits Innate.

A curious deviation from the harmony which prevailed throughout this Epeira brood was shown by the spider which made the above mentioned web and another who chanced to straggle upon it. The intruder passed along a radius toward the hub where the Orbweaver hung awaiting prey. The latter immediately turned and seized the radius with her feet, her little frame meanwhile showing in every part the vigor and expectancy of her kind when a victim strikes the web.

A series of pulls and counter pulls ensued; then the two araneads ap-

[1] M. H. Lucas, Bull. des Seances de la Soc. Entom. de France, No. 27, page 107, 1874.

proached. There was a sharp contact, a momentary whirl of confused legs, a retreat by the maker of the orb, who dropped from her snare quite to the table, where she lay in the characteristic mimicry of death.

Feigning Death Innate.

This behavior—conscious feigning or unconscious paralysis, as the case may be—is shown by the youngest spiders when they are touched upon their webs, or handled when off them. Like the aeronautic habit, swinging by dropthread and foot basket (Fig. 268), snare weaving, and enswathing the prey, it also springs into being as a perfectly developed instinct.

The intruder upon the snare followed the owner a little way towards the confines of her abandoned domain, then returned to the hub, and deliberately settled herself in the natural attitude, as much at home as though she had herself spun the orb. The little exile meanwhile recovered from her paralysis and climbed over to the standard of the lamp, where I left her. The actions of these two spiders showed the most determined hostility, and I have no doubt that, had either gained the mastery, the other would have been fed upon. On the contrary, those of the brood hanging upon the commons swung cheek by jowl without the slightest demonstration of a cannibal propensity. I believe that the ordinary brood fraternity is broken with the spinning of the first snare, at whose construction the natural solitary and ferocious character of the creature, and all its wonderful instincts, heretofore dominant, are vivified and spring into active exercise. Possibly the little chappies are as much surprised as their human observer to find themselves possessed of such strange powers.

CHAPTER IX.

THE AERONAUTIC OR BALLOONING HABIT.

Many accounts have been published, more or less valuable, of what are popularly known as "flying spiders." As the natural habits of familiar animals have come to be better understood, this popular phrase has yielded to the more accurate one, "ballooning spiders." However called, the habit referred to has been and remains interesting and attractive to the ordinary scientific observer. The fact that an animal which has none of the natural provisions for progress through the air granted to winged creatures, should, nevertheless, be able to overcome gravity, mount into the atmosphere, and accomplish aerial journeys, sometimes of immense distances, is certainly well suited to captivate the imagination, awaken curiosity, and stimulate research. This interest is quickened by the fact that the mode by which the spider aeronaut reaches these results bears a marked likeness to the artificial means by which man has himself solved the problem of aerial navigation. The thought that the invention of Mongolfier's mind possesses this striking analogue in the natural history of an inferior creature, strikes into a profounder depth than curious wonderment, and touches the problem of a Supreme Mind over Nature.

"Flying Spiders."

I.

I have studied the aeronautic habit of spiders from representatives of the Orbweavers, Tubeweavers, Citigrades, Laterigrades, and Saltigrades, and have not been able to note any difference in the mode of flight as practiced by all. It is probable that the young of most spiders, and many of the small species of all the great groups, are more or less addicted to such mode of motion. Certainly the habit is very strongly fixed in Orbweavers. Epeiroid spiderlings just out of the cocoon lift themselves into the air and sail away, precisely in the manner hereafter described. Indeed, the infant aranead, when separated from its fellows and exposed to a strong puff of air, seems instinctively to throw out its spinnerets and send forth jets of silken filament, just as a human baby sets in motion its feet and hands.

As the jets almost instantly acquire sufficient buoyancy to counterbalance the spider's weight, the creature becomes an aeronaut, nolens volens, and one can see how readily the deliberate habit of ballooning

could have been formed and fixed by heredity. The largest Orbweaver that I ever saw taking flight was a partly grown Domicile spider about the size of a marrowfat pea, say one-fourth inch long. After having floated over a field and above a hedge row, it crossed a road and anchored upon the top of a young tree. It never attained a height of over twenty feet, but moved quite as fast as I could run.

Velocity of Flight.

Young and small spiders fly rapidly, their motion depending, of course, upon the state of the breeze, although they do not appear to undertake their aerial voyage when the wind is strong. However, even when the air seems quite still to the observer, the little aeronauts find a sufficient current in the height to which they immediately ascend to bear them along with a good degree of speed. Indeed, I have been surprised at the velocity of their progress in the midst of what might be called a dead calm.

Seasons and Conditions.

Spider ballooning is not limited to a special period of the year, but may be practiced at any time. In point of fact, however, the seasons when it most prevails are the spring or early summer, and the autumn after the young have been hatched. The fall of the year is more especially the season for "flying spiders," and October the month most favored. But in early November also the balloonists are abroad, particularly during the Indian summer, or when a series of cool days is succeeded by a warm day.

II.

The following studies[1] were made during October, in fields adjacent to Philadelphia and in the adjoining Delaware County. The days were warm and bright, with a soft wind from the west, or a gentle breeze blowing, but not steadily from any quarter. Stooping low and glancing along the meadow, the eye caught the sheen of myriads of fine silken filaments glistening in the sunlight. The tops of grass spires and the bushy heads of tall weeds were netted together by innumerable threads, and from many points of the same filaments were streaming out at various lengths into the air. Numerous small spiders, chiefly Orbweavers, especially the young of Tetragnatha extensa, were rising from these plants and sailing over the field.

Elevation for Flight.

The finest exhibition of the aeronautic flight was seen along a post and rail fence which divided the meadow, and the description of this may be considered as covering the like behavior among all balloonists scattered over the fields. The tops of the fence posts were the favorite ascension points, and upon these clusters of young Lycosids were gathered, sometimes eight or ten in a group. The purpose in choosing these elevated spots is quite apparent, the currents of

[1] Proceedings Academy Natural Sciences, Philadelphia, 1877, page 308, sq.

air being stronger there than close to the surface of the earth, and consequently affording much better facility for flight. The presence of a deliberate and wise volition seems evident from the fact that the Lycosids are ground spiders, and not found habitually in such positions as the above. They had certainly mounted to the top of the fence with the settled purpose of taking advantage of the stronger breeze and better "send off" which the superior height afforded.

At least, it was easily determined that such an advantage did ensue from elevation. I selected some of the lower stalks of grass from which silken streamers were fluttering quite lazily. Close up to the stalk or blade I saw the spider placed back downward clasping the thread with its claws. Sometimes a thickened conical or flattened piece of silk marked this end of the line. When these grass stalks were broken off and lifted into the air the streamers fluttered out briskly and were soon snapped off, carrying the young araneads away with them. These experiments showed that the act of ascension is aided by elevation, both in these cases and in those where the spider mounts directly from the perch.

FIG. 270. Attitude of aeronautic spider just before taking flight.

The young Lycosids had generally chosen the very tops of fence posts as points of ascent, and fortunately this site suited the observer's convenience as much as the spider's, and I could therefore notice with comparative ease the methods of the miniature balloonists.

Posture Before Flight.

The spider's first action was to turn its face in the direction from which the wind was blowing. Then the abdomen was elevated to an angle of about forty-five degrees, and at the same time the eight legs were stiffened, thus pushing the body upward. In order to permit this movement the claws were brought in somewhat, but not beneath the body, so that when the legs were stiffened the body stood high above the surface. From the spinnerets at the apex of the abdomen a single thread or ray of threads was exuded, and rapidly drawn out by the breeze until, by reason of its delicacy, it was lost to sight. Four, five, even six or more feet of the lines would at times be in view. Gradually the legs were inclined in the direction of the breeze, and the joints straightened out. The foremost pair of legs sank almost to the

level of the post; and these especially, but indeed all the legs and the entire attitude of the creature, presented the appearance of an animal resisting with utmost force and tension of muscles the effort of some superior power to snatch it away.

Vaulting. Suddenly and simultaneously the eight claws were unloosened, and the spider mounted with a sharp bound into the air, and went careering away across the meadow, at a rate more or less rapid according to the velocity of the wind. The utmost care was used to determine whether in this upward bound the volition of the spider had any further agency than the simple unclasping of the feet from the post. Owing to the extreme difficulty of such an observation, I cannot speak with absolute confidence, but was able to satisfy my own mind that the aeronauts always vaulted upward and clear of the post at the moment of releasing their hold. I can hardly be mistaken in the belief that this was so in many cases, at least.

Frolicsome Spiderlings. A similar action was frequently observed during the preliminary and tentative movements in which the spiderlings indulged prior to the final flight. Something was noticed among them not unlike the frolicsome pranks of kittens or lambs. One would rush up to another, who thereupon would immediately change position, either by running or quickly vaulting to another part of the post. At times a leap would be made quite away from the post, but the buoyancy of the thread which had been exuded being insufficient to overcome the weight of the animal, instead of rising into the air, the creature returned to the post or struck upon the adjoining rail. In these and similar movements I was able to detect distinctly the vaulting action of the spider, and the eye, being thus familiarized with the movement, was less liable to be deceived in the more difficult observation of the quick spring at the time of the aerial flight.

Gossamer Threads. The posts and parts of railings adjoining were covered with threads adhering to the wood and streaming out into the air. These were the result in part of the feints at flight just referred to, but were partly owing to another cause. The spiders, previous to flight or vaulting, attached themselves to the post in the manner common to most of their order. The apex of the abdomen was thrust down upon the surface, and the liquid silk at the same time exuded from the spinnerets was thus caused to adhere thereto. As the creature moved away the thread was run out into line, and gave the spider a firm attachment. It is a question whether this anchorage is always made previous to flight, and whether the thread is cut immediately before the ascent. The observations made all pointed to an affirmative answer, but the matter was not positively settled.

The attempt was made to follow some of the aeronauts beyond the point of ascent. The difficulty in getting the minute objects in position

relative to the sun favorable for such observation, the motion of the air which carried them upward, as well as the rapidity of flight, frustrated many attempts. A position was finally taken beside one of the side posts of the sliding "bars," which being opened gave a point of observation with the back to the sun, the eye upon the object, and a fair opportunity to follow it without the delay of leaping over a high fence, which before had been between the observer and the course of the aeronaut sailing before the wind. Fortune favored patience, and at last a spider took flight in a line which was a little higher than the face.

Following the aranead at a moderate run, with the eye held closely upon it, I observed that the position of the body was soon reversed; that is, the head was turned in the direction toward which the wind was blowing, instead of the point from which it blew, as before the ascent. Thus the long thread which streamed out above the aeronaut inclined forward, and at the top was in advance of its head. I also observed that the legs were spread out, and that they had been united at the feet by delicate filaments of silk. The action by which the spinningwork was accomplished was not noticed, owing to the smallness of the creature, the rapidity of its movements, and the difficulty of such an exceptional mode of observation. But the fact was noted. Tne reason naturally suggested for it is the increased buoyancy resulting from the increased surface thus offered to the resistance of the air, provided, of course, any reason be required beyond the animal's need of some sort of foothold while afloat. Mr. Emerton,[1] in the course of some accurate observations of ballooning spiders, says that the most of them while afloat hung by their spinnerets only, and drew their legs close against their bodies, a posture which I have also sometimes observed.

Fig. 271. Fig. 272.

Fig. 271. Attitude of ballooning spider just after taking flight. Fig. 272. Attitude when floating before the breeze.

The spider whose behavior I am now describing was followed for a distance of eighty feet, when it gradually settled downward upon the meadow. Before, or rather during, this ascent a small, white, flossy ball of silk was seen accumulating at the mouth, which, with the peculiar motion of the fore feet, palps, and mandibles, at once suggested the drawing in of a thread. This behavior is not infrequent with spiders under other circumstances; indeed, it may nearly always be observed when webs are being

[1] "Flying Spiders," American Naturalist, 1872, pages 168–9.

cleared away, and during ascent upon a dropped dragline after a spider has thrown herself from her snare. But it became especially interesting at that moment, for at once it suggested an act of volition on the part of the Lycosid, by which, in a measure at least, it might control its descent. Evidently the shortening of the overhanging thread operated like the furling of sails upon a vessel, and decreasing the motion of the spider increased the influence of gravity upon the body, which thus sank toward the ground. At the same time, the diminution of the surface of the thread above, and the increase of bulk at the mouth (trifling as it might be), tended to increase the buoyancy of the whole, and allowed the creature to fall. The same effect was thus produced by the spider aeronaut, and by a strikingly analogous mode, as that which the human aeronaut accomplishes when he contracts the surface of his balloon by causing the inflating gas to escape.

Controlling the Descent.

The manner in which the lines of spiders are carried out from the spinnerets by a current of air appears to be thus: As a preparatory measure, the spinnerets are brought into close contact, and the liquid silk is emitted from the spinning tubes; the spinnerets are then separated by a lateral motion, which breaks up the silk into fine filaments; on these filaments the air current impinges, drawing them out to a length which is regulated by the will of the animal; and, on the spinnerets being again brought together, the filaments coalesce and form a compound line.[1] According to Mr. Emerton,[2] the line seems to come from the middle pair of spinnerets only, but the posterior pair were in constant motion, folding together over the middle ones and then spreading apart as if to help throw out the threads.

How Filaments are Emitted.

FIG. 273. FIG. 274.

FIG. 273. Floating with head depressed, holding to a foot basket. FIG. 274. Ballooning spider gathering in its threads for descent.

III.

It will here be in place, and will add to the understanding of the reader, to insert a few field notes giving in detail the above and some further facts as to the posture and action of spiders before and during flight.

[1] "Blackwall on the Structure, Functions, and Economy of the Araneidea," Ann. and Mag. of Nat. Hist., Vol. XV., page 241, 1845.

[2] "Flying Spiders," American Naturalist, 1872, page 168.

There is no difference between the aeronautic habit of these araneads and that of spiders in other parts of the United States. Moreover, observations of naturalists on ballooning spiders in various quarters of the globe show that the same methods everywhere prevail. It will be further observed that the notes relate chiefly to Lycosids, which appear to be universally addicted to the ballooning habit. This is probably true of all Citigrades. It is worthy of special notice that these ground spiders, when seeking aeronautic flight, take pains to seek some elevated spot as a point of departure. This is not limited to the Lycosids, for Mr. Enock speaks of young Atypinæ in England securing an easy and unobstructed flight in the same way. The instinctive impulse which urges spiderlings to leave their resorts on the ground and seek spots essential for favorable ascent, certainly has the appearance of reasoning intelligence. At all events, the younglings, by whatever process they reach the conclusion, do the best thing possible to aid their ballooning enterprise.

Fig. 275. Ballooning Lycosids ascending from a fence post, and floating before the wind.

Example No. 1. A young Lycosid, apparently Lycosa scutulata Hentz, was posed on the side of a fence post opposite the wind, face downwards, abdomen elevated, the body raised by the legs. I followed it after flight for two hundred feet; it rose as high as thirty feet before it was lost to sight. Its flight was across a wide meadow, and promised to be a long one. Several threads were streaming out and up behind and before the spider.

No. 2. A Saltigrade, probably the young of Astia vittata, was posed on the side of a fence board opposite the wind. Its legs were elevated, thus raising up the body; the abdomen was turned well nigh straight upward; a long thread floated out and up from the spinnerets. The spider walked several inches upward along the rail, keeping its body in the same stilted position, the thread meanwhile flying. Then it was off, rather slowly, and about on a line with my face. It showed, in motion, one small thread in front and one (or more) behind. It moved straight

forward for about fifty feet, and then rose suddenly upward, as though it had passed into an ascending current of air.

No. 3. Lycosa; observed at 2 P. M. Pose and actions as No. 1. After flight I distinctly saw one thread before and (apparently) two behind; the head was toward the wind. After sailing fifteen feet it rose up and out of sight, a long stretch of meadow before it. Once, before it mounted, it lifted up one hind foot, as though laying hold upon the stay thread.

No. 4. Lycosa; this example was followed for a distance of forty or fifty feet; in front of it there appeared to be but one thread, a ray of several fine diverging threads floated behind from the spinnerets. Its back was toward the ground. Its abdomen seemed, but could not be certainly determined, to be riding in front, i. e., toward the direction of the wind. The body of the spider was thus at the apex of the angle formed by the fore and hind filaments, the free points of which were quite far apart. The balloon struck a tree, and part of it went on, the spider apparently staying on the tree.

No. 5. Lycosa; this specimen floated with the abdomen toward the point of departure. Several threads ascended from it, one thread in front; the feet were gathered together; but, apparently, the back was upward. It crossed the highway, and a carriage just then passing interfered with the observation.

No. 6. The head rode in front, the back was certainly toward the ground. A fourfold streamer of threads was thrown out before mounting. At first the spider moved off slowly, but soon climbed up the fore thread, the "bow," so to speak; further on it climbed up the rays of threads a distance of several inches. The balloon, when lost sight of, had at least three separate filaments. It was followed one hundred feet before it rose out of sight.

No. 7. Lycosa; riding back downward; it sailed sidewise part of the time; afterward the head seemed to be directed toward the course of the wind.

Before vaulting into the air many of the spiderlings turned their elevated abdomens first to one point then to another; repeating the action many times, as though testing the direction of the wind.

The Process Summarized.

The whole process of aeronautic flight, as it has been described, may be briefly given as follows: First, the spider seeks a high position, such as the top of a bush, grass stalk, or fence post, as the point of ascent. Second, the abdomen is elevated to as nearly a right angle with the cephalothorax as may be. Third, a ray of threads is issued from the spinnerets, the face being meanwhile turned to various points; the legs are stretched upward, thus raising the body; fourth, they gradually incline in the direction of the breeze, the joints straighten out, the legs sink forward and down until the first pair are almost on a level with the surface, the whole attitude of the animal being that of one resisting some

force exerted from above. Fifth, suddenly and simultaneously the eight claws are unloosed, and the spider mounts with a sharp bound, apparently, and (sixth) floats off with the back downward, usually, but sometimes with this position reversed. Seventh, at first the abdomen seems to be in advance, but generally the body is turned so that the head rides in front. Eighth, the ray of threads is apparently grasped with the feet and floats out in front, upon which (ninth) sometimes the spider will climb upward, as though to adjust the centre of gravity. Meanwhile (tenth) a thread or cluster of threads issue from the spinnerets and float out behind, leaving the spider to ride in the angle of the two diverging rays, or, as it sometimes happens, of three, which are widely separated at the upper free ends. Eleventh, the feet seem to be united by delicate filaments, which would serve to increase the buoyancy of the balloon. Twelfth, the spider is now carried forward by the wind, riding for long distances in an open space, and often borne high upward upon ascending currents. Thirteenth, the anchorage of this miniature balloon appears at times to be within the spider's own volition, by the fact that it can draw in with its claws the forward ray and gather it in a white roll within the mandibles. But most frequently the balloonist is stopped by striking against some elevated object, or by the subsidence of the breeze. A bright warm day in October is commonly chosen for the ascent, and judging from the presence of a number of dry moults, apparently of the same species of spider observed in flight, the animals had recently cast their skins.

IV.

The Height of Ascents.

The greatest height to which I have seen spiders ascend is about one hundred and fifty feet; but, undoubtedly, they often rise much higher. Dr. Lincecum observed the gossamer balloons of certain Texas species floating at an altitude of one to two thousand feet.[1] Blackwall found ascending currents of air acting with such force upon the gossamer streamers as to raise them in the atmosphere to a perpendicular height of at least several hundred feet.[2] Dr. Martin Lister, the earliest observer of the habit (A. D. 1670), says: "As to the height they are able to mount, it is much beyond that of trees or even the highest steeples in England. This last October the sky here upon a day was very calm and serene, and I took notice that the air was very full of webs. I forthwith mounted to the top of the highest steeple[3] in the Minster [York], and could thence discern them yet exceeding high above me; some that fell and were entangled upon pinnacles, I took and

[1] "The Gossamer Spider," American Naturalist, 1874, page 592.

[2] Trans. Linn. Society, Vol. XV., page 453.

[3] The central and two western towers are 201 feet high. Cathedrals and Abbeys of Great Britain, Dr. Wheatley.

found them to be lupi [Lycosids], which seldom or never enter houses, and cannot be supposed to have taken their flight from the steeples."[1] I once found a number of half grown Epeiras upon their round webs on the topmost railing of the dome of St. Peter's at Rome (Italy), whither they or their maternal ancestor had doubtless been carried by the wind from the surface of the earth.

Floating Gossamer

October 25th, 1883, was a bright day following a series of cold, wet days caused by a severe northeast storm. At noon, while crossing the Chestnut Street Bridge, Philadelphia, I saw a great number of aeronautic threads floating in the air, streaming from the tips of the bridge balustrade and lodged upon the piers. One of the threads, a long filament, was sailing slowly toward the river as a Pennsylvania Railroad train dashed along the river track beneath the bridge. It was low enough to strike the cars as they rolled by, and so was carried on southward with its tiny voyager—another illustration of how artificial habits of man tend to the geographical distribution of life. The filaments were long, pure white, curled or wrinkled, about one millimetre wide or less, occasionally expanded into thicker wads, and frequently carried attached to them minute insects which had doubtless entangled in the fibres as the threads floated in the air. (Fig. 280.) On one thread I found three, on another two small flies. The young balloonist is thus provided with food upon his landing, if he choose to avail himself of these chance supplies. The insects are simply entangled, as the fibre is without viscidity.

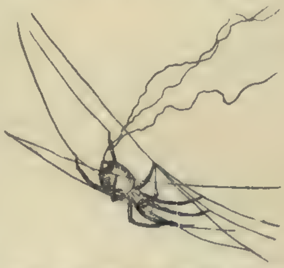


Fig. 276. Young spider sending out aeronautic threads while hanging upon a web.

Young Spiders.

The field observations recorded above have been confirmed by numerous studies made with spiderlings reared in the house, especially the young of Epeira sclopetaria, Epeira domiciliorum, Epeira insularis, and Agalena nævia. As the results obtained were not different from those already given, they require but brief mention. When let loose into the air from the finger tip, the spiderlings floated out by a single thread, which was always and instantly first attached to the finger. At first the head was outward, the abdomen being turned toward the hand, from the apex of which the long superior spinnerets of the tubeweavers diverged. Presently the little creature turned and cast out a thread behind, when, if permitted, it would usually clamber up the original thread to the finger. When this was broken off, the spider, seated midway of the two filaments, floated off and outward, and was lost to sight. Again, by an eddy of the air, the thread would be thrown backward and upward and catch against the wall, upon which the little voyager would anchor.

[1] Correspondence of John Ray, page 77. Lister to Ray, January 20th, 1670.

At other times, much to my surprise, after the thread had been quite lost to view, the spider was supposed to be far away upon its flight, it would descend as from the clouds, and send out its silken grapnels against the cheek or nose. The will of the little spider seemed to have no control over these movements, which apparently were always wholly at the mercy of the wind. However, the manner of accomplishing aerial flight by means of the buoyancy of a single thread, or rather of two threads united at or near the middle, was quite in accord with the methods above described.

V.

While the young balloonists were adventuring their flight in the fields in the manner heretofore described, several species of small Orbweavers were making or waiting for their ascension in a manner so different that it requires especial notice. These were stationed upon the small grasses and weeds, from which innumerable cords of spider silk were streaming, and upon which similar threads were twisted and meshed by the eddies of the wind and the passing of the spiderlings from point to point. The attitude of most of these was one of expectation. Only two were observed in actual flight, and one of these I assisted. The nearness to the ground and the shelter of surrounding herbage doubtless retarded the process. However, this greater deliberateness is quite in harmony with the more phlegmatic Orbweavers, just as the energy of the Lycosids in mounting the fence and their haste to be off are characteristic of that group.

FIG. 277. Aeronautic Orbweavers preparing to ascend from floating threads.

Variations: Orbweavers. The little Orbweavers were hanging upon the lower part of the floating strings near the point of attachment to the grass. Their backs were downward and their heads outward, or toward the free end of the thread. (Fig. 276.) The first, second, and fourth pairs of legs were stretched along the thread, and the third and shortest pair

were held off, curved, the feet apparently united to the main thread by taut filaments. This position, as far as could be determined, was maintained after flight. In some cases a series of two or three puffs or pellets of floss were gathered around the thread between its free end and the spiderling. They were generally cone shaped, the apex being turned toward the animal. In form they were not unlike the pellets which one used to see gathering upon the roll of wool as it passed from the fingers of our maternal ancestors into the whirling "flyers" of an old fashioned spinning wheel. (Fig. 277.) Perhaps they may have been wrought by a similar process, the twisting of the loose threads through the action of the wind and the counteraction of the spider. The continuation of such twisting must presently break the thread, and thus set the occupant afloat. The greater force of the wind secured by gently breaking a stalk and lifting it into the air soon snapped off a thread, carrying the little aranead away with it.

Flossy Balloons.

I am inclined to think that this mode of ballooning prevails, particularly among Orbweavers; that is to say, the spider, having spun out a long thread, sometimes thickened at the attached end, lays hold upon it and waits for the wind to pull it loose, when it is borne away and aloft. It is even probable that the spider may cut the thread, and thus procure her own release. This would place the moment of ascent within her own volition, and the fact (should it be established) would add greatly to the interest with which one must regard this variation in the aeronautic habit of these interesting araneads.

Dr. Gideon Lincecum has put upon record a case in point.[1] He describes the balloon of a Texas Orbweaver, which he calls the "Gossamer Spider," as follows: A lock of white gossamer five or six inches long and two inches wide in the middle, tapering toward the ends, is attached to a stalk, bush, or other elevated object by a thread two or three inches long. At the free end or "bow," two lines thirty or forty feet long are spun out, and one twenty or thirty feet long is spun from the attached end or stern of the aerial craft. All being ready for ascent, the voyager cuts the cable which holds the balloon, and floats briskly upward and forward on an inclined plane, or bounds aloft with a sharp spring that eludes one's efforts to stop it. Lincecum's description of the hammock shaped balloon and its float lines answers very well to the above described aeronautic spinningwork of Orbweavers (Fig. 277), and I am disposed to accept as quite trustworthy the statement that the attached end was actually severed by the spider, who thus controlled, in some measure, the period of her ascent.

A Texas Spider Balloon.

Blackwall had already observed that occasionally spiders may be found on gossamer webs after an ascending current of rarefied air has separated

[1] American Naturalist, 1874, page 595.

them from the objects to which they were attached, and has raised them into the atmosphere. He, however, added the opinion that, "as they never make use of them intentionally in the performance of their aeronautic expeditions, it must always be regarded as a fortuitous circumstance."[1] This opinion, I think, must be abandoned, and the conclusion reached that there are two modes of ballooning practiced by spiders, viz.: First, ascent by means of the buoyancy of lines issuing directly from the spinnerets, the aranead vaulting upward from its perch; and, second, the ascent upon lines, sometimes thickened by flossy tufts or strands, which are first spun out and attached to fixed objects, and afterward released by the force of the wind or cut loose by the spider.

Modes of Ballooning.

VI.

While arranging a collection of spiders in the Academy of Natural Sciences of Philadelphia, I discovered a number of specimens of a large Laterigrade, the Huntsman spider, Heterapoda venatorius, from various localities, as represented upon the accompanying tables and chart. (Fig. 278.) Starting with the specimens in my private collection, the line of distribution was traced from Santa Cruz, Virgin Isles, to Cuba, to Florida, across Central America, Yucatan, and Mexico; across the Pacific Ocean by way of Sandwich Islands, Japan, and Loo-Choo Islands; and thence across the continents of Asia and Africa to Liberia. The line thus indicated extends from the extreme eastern limit of North America to the extreme western coast of Africa, thus girdling the globe, with the exception of 54° of longitude. This excepted area expresses substantially the width of the Atlantic Ocean.

Aerial Circumnavigation.

It occurred to me, when this fact became apparent, that this line of distribution is within the belt of the North Trade Winds; and, further, that there might be some connection between the two facts and the fact that Laterigrade spiders, to which group this animal belongs, are among those which are most addicted, in the earlier stages of growth, to balloon migration. Thereupon I referred to the general course and limits of the North Trades, which are roughly indicated in the chart (Fig. 278) by the two upper lines of arrows, marked (at the ends) A A and B B. In the Atlantic Ocean the North Trade Winds prevail between latitude 9° N. and 30° N.; in the Pacific between 9° N. and 26° N. We now may turn to the chart, in which the following geographical points (shown by black spots and figures) are represented by our spider. The specimens which have been examined in the Academy, and my own collections, whose habitats are personally known, are marked by an asterisk (*).

The species is credited to the other localities named on the authorities given therewith.

[1] Blackwall, Spiders of Gt. Br. and Ir., Introduction, page 12.

A comparison of this table with the chart will at once show that the dotted lines in the latter, which indicate the geographical belt over which Venatoria is distributed correspond, with remarkable general exactitude, with the belt over which the North Trades blow. It is not, therefore, an improbable conjecture that this distribution has been accomplished by means of those winds and the spider's habit of aerial flight. It is, of course, supposable that commerce, following largely the same belt, may have originated or aided this distribution. But certain facts in the history of the spider seem to forbid this hypothesis.

Not Artificial Distribution.

Some of the facts are: First, the early discovery of the species as already widely distributed; second, its presence at so many different insular points nearly or altogether contemporaneously with first visits by commercial nations; third, the existence of the species or its close allies among the fauna of the tropical interiors of continents far distant from coast lines; fourth, the variations, chiefly in color, which have been observed, and which would seem to require for their development a longer period than that which has transpired since the commencement of commercial communication with the localities in which the variations have been wrought. While one may not conclude with absolute certainty from these facts, they warrant the theory that the Huntsman spider has become cosmopolitan by the action of Nature, independent of the aid of man.

TABLE OF DISTRIBUTION NORTH OF THE EQUATOR.

LOCALITY.	LATITUDE.	LONGITUDE (GR.).	AUTHORITY.
1. Palmyra Island	6° N.	163° W.	*
2. Pelew Islands	7°– 8° N.	134° E.	L. Koch.
3. Loo-Choo Islands	25°–29° N.	128° E.	*
4. Japan	30°–40° N.	130°–140° E.	*
5. Nicobar Islands	6°–10° N.	96°– 97° E.	Böck.
6. Tranquebar, India	12° N.	80° E.	Fabricius.
7. Liberia, Africa	5°– 9° N.	10° W.	*
8. Senegal, Africa	17° N.	16° W.	Walckenaer.
9. Martinique, North America	15° N.	61° W.	*
10. Santa Cruz	18° N.	65° W.	*
11. Jamaica	18° N.	77° W.	Walckenaer.
12. Cuba	20°–23° N.	74°–85° W.	*
13. Florida	30° N.	81° W.	*
14. Yucatan	20° N.	82°–91° W.	*
15. Mexico, Jalapa	20° N.	97° W.	*
16. California	?	109°–117° W.	L. Koch.
17. Oahu, Sandwich Islands	20° N.	155°–160° W.	*

A Prediction.

I was so impressed by the above chain of facts, and so confident of the inference therefrom, that I ventured to predict that corresponding results would follow a comparison of specimens collected from all quarters; that is to say, they would be found to lie within the belt of the North or South Trade Winds. The only specimens at

hand were those cited above, and from Zululand and Surinam. But I was able to pursue the matter by reference to locations given by a number of naturalists. I was aided in this by references kindly sent me by Mr. William Holden. Some of the localities thus obtained have been named above, and others were found to correspond with the points represented by the specimens examined. So far my conjecture was verified.

The two lower arrow lines in the chart, C C and D D, give a general view of the course and limits of the South Trades, which prevail in the Atlantic Ocean between latitude 4° N. and 22° S., and the Pacific between latitude 4° N. and 23½° S.[1] It is, of course, understood that these limits are not stationary, but follow the sun, moving northward from January to June, and southward from July to December; an oscillation which is also indicated in the zone of distribution. They are, however, substantially as above given, and may be compared with the following table, which shows the southern geographical distribution of this species, according to the authorities cited therein:—

TABLE OF DISTRIBUTION SOUTH OF THE EQUATOR.

LOCALITY.	LATITUDE.	LONGITUDE (GR.).	AUTHORITY.
1. Viti Levu, Fejee Islands	16° S.	180° W.	L. Koch.
2. New Caledonia	20°–22° S.	163°–162 E.	"
3. Sidney, Australia	33° S.	150° E.	Böck.
4. Australia	11°–30° S.	105°–115 E.	L. Koch.
5. Singapore	2° N.	104° E.	Walck.
6. Zanzibar, Africa	6° S.	40° E.	Gerstaecker.[2]
7. Southeast Equatorial Africa	10°–20° S. (?)	30°–50° E.	Blackwall.
8. Mauritius	20° S.	56° E.	Walckenaer.
9. Madagascar	8°–26° S.	43°–50° E.	Vinson.
10. Zululand	20° S.	28° E.	*
11. Pernambuco	7° S.	37° W.	
12. Brazil		37°–70° W.	Simon, Walck.
13. Rio Janeiro	23° S.	50° W.	Walck.
14. Surinam	6° N.	55° W.	*
15. Valparaiso, Chili	33° S.	70° W.	L. Koch.
16. Tahiti, Huaheine, Society Islands	18° S.	150° W.	"
17. Rarotonga, Cook's Islands	22° S.	162° W.	"
18. Upolu, Navigator Island	13½°–14½° S.	168°–173° W.	"
19. Tongatabu, Friendly Islands	20° S.	172°–176° W.	"

This table shows a distribution corresponding with the limits of the South Trades, with, in three cases, viz., Sidney (3), Surinam (14), and Valparaiso (15), a slight oscillation in accord with a fact above stated. Thus

[1] The arrow line which indicates the course of the Trades is intended to give only the general direction. In point of fact, however, that course, in the case of the Southern Trades, is more nearly conterminous with the line of distribution than here shown. The arrow line should not run directly westward from Valparaiso, Chili (No. 15), but from a point 10° above it, passing just south of Friendly Isles (No. 19).

[2] Gerstaecker speaks of species as distributed over a large part of Africa, Asia, and South America. See Von der Decken's Travels in East Africa, III., ii., page 482.

Fig. 278. Chart to show the circumnavigation of the globe by the Huntsman spider, in the course of the Trade Winds.

was entirely fulfilled the expectation with which I entered upon the preparation of these comparative tables.[1]

It may not be without interest, and may, perhaps, have some bearing upon the above theory of distribution, to remark that the genus (or a closely allied genus) to which Heterapoda venatoria belongs is probably one of the oldest known forms of the spider fauna. Thorell[2] places the now existing genus Heterapoda (Ocypete, Koch; Oxypete, Menge) among those which are represented in the amber spiders. Amber probably belongs to the tertiary (oligocene) period, and in it numerous spiders are found, generally well preserved. How far any supposed contiguity or closer approach of continents now separated might have facilitated or occasioned the world round distribution of our Huntsman spider, is a point upon which geologists may more properly express an opinion.

Variation of Species by Distribution.

The question, what variation of species, if any, occurs in the course of this distribution, is of great interest. The specimens examined by me show no variations which may not come within the range of those natural differences which obtain in many species. Most of the specimens had been so long in alcohol as to obliterate any differences in color and markings which might have existed. The normal color is a uniform tawny yellow, varied upon the cephalothorax by a circular patch of blackish or blackish brown color covering nearly two-thirds of the space; and, further, by a white or whitish marginal band quite or nearly girdling the same. In some of the specimens this circular patch seems to have been more or less of a brownish color. Gerstaecker[3] speaks of this species as distributed over a large part of Africa, Asia, and South America. Specimens were examined by him from Dafeta, Mombas, and Zanzibar. In these there was some variation in the coloration of the maxillary palpi: on the one hand, from a light rust color to brownish red and pitch brown; on the other hand, to a more or less sharp division or limitation of the light yellow color of the anterior and posterior borders of the cephalothorax. There was also a browning of the region about the eyes. But the araneologist will not regard such differences as having any special value as specific characters.

[1] When these studies were originally announced in the Philadelphia Academy, I had no specimens from the South Pacific Islands within the same general belt; nor from the chain of small islands between the Sandwich Islands and Asia, viz., Philadelphia, Drake, and Massachusetts Islands, Anson and Magellan Archipelagoes; nor the Cape Verde and St. Helena Islands, off the west coast of Africa. Nevertheless, I expressed the belief that these had all been stations in the line of migration, the latter across the Atlantic Ocean as the Antilles have been; the former across the Pacific, as the Sandwich Islands, Loo-Choo Island, and Japan have been, and as Mauritius and Madagascar Islands have been across the Indian Ocean. Moreover, I ventured the prediction that a more diligent search would prove that this cosmopolitan species exists, and probably had already been collected at some of the above points.

[2] European Spiders, page 231, Nov. Acta. Reg. Soc. Sci., Upsal., 1870.

[3] Von der Decken's Travels in East Africa, III., ii., page 482.

VII.

There seems nothing improbable in the theory of aerial circumnavigation suggested to explain the series of facts above presented. There are not, indeed, many recorded observations of the distances to which spiders are carried out to sea in their aeronautic flights. But, before a strong steady wind, or in cases of storm, it is possible that the greatest distances which appear in the tables could be overcome. An observation of Mr. Darwin is the only recorded one to which I can refer.[1] At the distance of sixty miles from land, while the "Beagle" was sailing before a steady, light breeze, the rigging was covered with vast numbers of small spiders with their webs. The little spider, when first coming in contact with the rigging, was always seated upon a single thread. While watching some that were suspended by this filament, the slightest breath of air was found to bear them out of sight. I have observed similar single threaded "balloons" sailing at considerable height

Spiders at Sea.

FIG. 279. The Huntsman spider; a male. C, the female's cocoon.

above the surface of the earth, and know no reason why, with a favorable breeze, they might not have been carried hundreds of miles. That they were carried at least sixty miles, as Mr. Darwin's testimony shows, and that before a light breeze, gives great probability to such a conjecture. It is to be noted, moreover, that the spiders arrested by the "Beagle's" rigging were evidently moving on when so stopped, and some of them, when arrested, soon resumed their flight across the main.

I am able to add a valuable observation in the same line as that of Dr. Darwin's. The late Capt. George H. Dodge, of the American Line steamer "Pennsylvania," informed me, during a voyage across the Atlantic in the winter of '81–2, that he had found the masts and rigging of his

[1] Voyage of the Beagle, Vol. III., page 187.

vessel covered in the same way with innumerable webs of spiders, while sailing during the month of March along the eastern coast of South America. His ship was more than two hundred miles from land and about four hundred miles south of the equator. The wind at the time, according to his recollection, was blowing from the westward; that is, from the continent. Captain Dodge, at my request, communicated the facts in writing, the incident having been impressed upon his memory by the strangeness of seeing such creatures so far out at sea. "The spiders seemed like little elongated balls, with a sort of umbrella canopy above them. They settled upon the sails and rigging, and, finally, disappeared as they came."[1]

Distribution.

The purpose of such a remarkable habit as these facts exhibit is, doubtless, to secure the distribution of species throughout wide regions. The buoyant filaments of spider gossamer serve the tiny arachnid the same good office that is rendered the dandelion and thistle seed by the starry rays of down surrounding them.

VIII.

The ballooning habit of spiders gives a complete explanation of a natural phenomenon which has attracted the attention of men from an early period, and which has been variously alluded to in prose and poetical writings, viz., Showers of Gossamer.

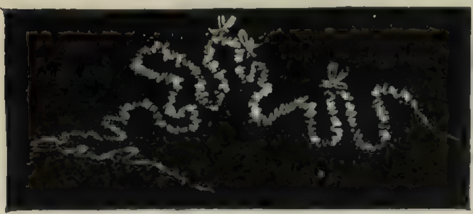


FIG. 280. A flocculent thread of gossamer, with small flies entangled.

Gossamer Showers.

One who walks the open fields in the latter part of September or in the soft bright days of October, which is the most delightful period of our American year, will notice great quantities of spider silk trailing and floating from the stalks of weeds and grasses, and indeed from all elevated objects. In the early morning, when the dew deposited upon these filaments betrays their presence, one will be surprised at the vast amount visible. Further on in the day he will observe quantities of this threaded spinningwork sailing through the air. (Fig. 280.) A great excess of these floating tufts and filaments constitutes what is commonly known as a gossamer shower. Doubtless Pliny alluded to such a phenomenon in the statement which he makes[2] that "in the year that L. Paulus and C. Marcellus were consuls it rained wool about the castle Carissa, near to which, a year after, T. Annius Milo was slain."

[1] Captain Dodge adds, very significantly: "You know that it is not unusual for birds to be blown out to sea. How much easier for a spider, provided he had the means to keep himself suspended in the air!"

[2] Natural History, II., 54. Holland's translation, page 27.

In later days, among our English ancestors, an explanation of this phenomenon even stranger than Pliny's prevailed and found expression through some of the English bards. For example, Spenser writes:—

> "More subtle web Arachne cannot spin;
> Nor the fine nets, which oft we woven see,
> Of scorched dew, do not in th' ayre more lightly flee."[1]

Still later Thomson in his "Seasons" utters the same idea:—

> "How still the breeze! save what the filmy threads
> Of dew evaporate brushes from the plain."[2]

We have, however, passed beyond the period when so simple a natural phenomenon could be accounted for on such an impossible theory as that of autumnal dews scorched by the sun.

I have never been so fortunate as to observe anything that could be called a "shower" of gossamer, although I have seen quantities of the material afloat in the air or fluttering from the foliage. I will therefore quote from others a description of the phenomenon. Mr. Kirby describes the gossamer observed by him early in the morning as spread over stubbles and fallows, sometimes so thickly as to make them appear as if covered with a gauzy carpet, or rather overflown by a sea of gauze, presenting, when studded with dewdrops, a most enchanting spectacle.[3]

Rev. Gilbert White, whose "Natural History of Selborne" has been so long and deservedly popular, describes such an incident as occurring in England on September 21st, 1741. At daybreak he found the stubble and clover grounds matted all over with a thick coat of cobwebs, in the meshes of which a heavy dew hung so plentifully that the whole face of the country seemed covered with two or three fishing set-nets drawn one over another. The dogs were so blinded by this deposit that they could not hunt, but lay down and scraped the encumbrances from their faces with their fore feet. "As the morning advanced," writes the author, "the sun became bright and warm, and the day turned out one of those most lovely ones which no season but autumn produces, cloudless, calm, serene, and worthy of the south of France itself. About nine, an appearance very unusual began to demand our attention—a shower of cobwebs falling from very elevated regions, and continuing without any interruption, till the close of the day. These webs were not single filmy threads, floating in the air in all directions, but perfect flakes or rags; some near an inch broad, and five or six long, which fell with a degree of velocity that showed they were considerably heavier than the atmosphere.

Material of the Shower.

[1] Faerie Queene, B. 2, XII., s. 77. [2] Seasons: Summer, I., 1209.

[3] Kirby and Spence, Introduction to Entomology, Vol. II., 341, Letter XXIII.

"On every side, as the observer turned his eyes, he might behold a continual succession of fresh flakes falling into his sight, and twinkling like stars, as they turned their sides towards the sun."

This shower extended over at least eight miles of territory, for Mr. White received an account from a trustworthy gentleman living that distance from his house, corroborating his own observation. This gentleman met the gossamer shower while he was riding abroad, and, concluding that he could escape it by mounting a hill above his fields, which was three hundred feet in height, rode to that point. But, to his astonishment, when reaching this lofty spot, he found webs apparently still stretched as far above him as before, still descending into sight in a constant succession and twinkling in the sun as they fell. Neither before nor after, says Mr. White, was any such a fall observed; but on this day the flakes hung in the trees and hedges so thick that a diligent person sent out might have gathered baskets full.[1]

Extent of the Shower.

Another account, quite as noteworthy as the above, was reported in the "London Times" on October 9th, 1826, which I quote from Mr. Frank Cowan's interesting and valuable "Curious Facts."[2] "On Sunday, October 1st, 1826, a phenomenon of rare occurrence in the neighborhood of Liverpool was observed in that vicinage, and for many miles distant, especially at Wigan. The fields and roads were covered with a light filmy substance, which, by many persons, was mistaken for cotton; although they might have been convinced of their error, as staple cotton does not exceed a few inches in length, while the filaments seen in such incredible quantities extended as many yards. In walking in the fields the shoes were completely covered with it, and its floating fibres came in contact with one's face in all directions. Every tree, lamp post, or other projecting body had arrested a portion of it. It profusely descended at Wigan like a sheet, and in such quantities as to affect the appearance of the atmosphere. On examination it was found to contain small flies, some of which were so diminutive as to require a magnifying glass to render them perceptible. The substance so abundant in quantity was supposed by the writer who described the phenomenon to be the gossamer of the garden or field spider, often met in fine weather in the country, and of which, according to Buffon, it would take 663,552 spiders to produce a single pound."

Another English Shower.

An English writer[3] describes what he calls a "Visitation of Spiders," which occurred at Newcastle-on-Tyne. Three miles of iron railing in the writer's neighborhood was covered with the little creatures. They were equally numerous about one mile north of Newcastle, and, in fact, covered

[1] Natural History of Selborne, Letter LXV.

[2] Curious Facts in the History of Insects, including Spiders and Scorpions.

[3] "Science Gossip," December 1st, 1865, page 282.

the entire town. A gentleman from Hexham, a town twenty miles from Newcastle, reported that they were abundant there also. The spiders were unknown up to that time, Mr. Blackwall not having described them in his elaborate work on the "Spiders of Great Britain and Ireland," only having noticed them in the "Annals of Natural History" in 1863, previous to which time they had not been observed in England. No one had observed this spider in the neighborhood of Newcastle up to the time of their appearance, and they disappeared as suddenly as they came. According to Mr. Blackwall, the spider is an aeronautic species, Neriene dentipalpis.

Blackwall's Description.

One of the most temperate descriptions of a gossamer shower I quote from Mr. Blackwall. A little before noon on an October day which was remarkably calm and sunny, with the thermometer in the shade ranging from fifty-five to sixty-four degrees, Mr. Blackwall observed that the fields and hedges in the neighborhood of Manchester, England, were covered over with a profusion of fine, glossy lines, intersecting one another at every angle and forming a confused kind of network. So extremely numerous were these slender filaments that in walking across a small pasture his feet and ankles were thickly coated with them. It was evident, however, notwithstanding their great abundance, that they must have been produced in a very short space of time, for early in the morning they had not attracted his notice.

Formation.

A circumstance so extraordinary could not fail to excite the curiosity of so keen an observer. But what more particularly arrested his attention was the ascent of an amazing quantity of webs of irregular and complicated structure, resembling raveled silk of the finest quality and clearest white. They were of various shapes and dimensions, some of the longest measuring upwards of five feet in length and several inches in breadth in the widest part, while others were almost as broad as long, presenting an area of a few square inches only. Mr. Blackwall quickly perceived that these gossamer threads were not formed in the air, as was generally supposed at that time (1826) even among naturalists, but at the earth's surface. The lines of which they were composed being brought into contact by the mechanical action of gentle airs, adhered together, until by continual additions they were accumulated into flakes or masses of considerable magnitude. On these masses of spinningwork the ascending current, occasioned by the rarefaction of the air contiguous to the heated ground, acted with so much force as to separate them from the objects to which they were attached, raising them in the atmosphere to a perpendicular height of at least several hundred feet.

About midday Mr. Blackwall collected a number of these webs as they arose, and again in the afternoon, when the upturned current had ceased to support them and they were falling. Scarcely one in twenty contained a spider, though on minute inspection he found small winged insects,

chiefly aphides, entangled in most of them. This flight of gossamer appears to have been quite general throughout Great Britain, as it was noticed in England, Wales, and even in Ireland.[1]

Mr. Blackwall is undoubtedly correct in the suggestion which he makes as to the origin of gossamer showers. My own observations, at least, are precisely in the direction of his conclusion. As has already been said, the aerial excursions of spiders in the United States usually occur in the soft, balmy days of early autumn, during the months of September and October, although they occur in a less degree during the first warm days of June. The reasons for this are manifest. In the first place the conditions of the atmosphere are favorable. The balmy weather invites the spiders to issue from their hiding places and attempt aerial flight. The wind is not high enough to disturb their excursions, and yet the temperature is sufficiently high to cause ascending currents of air. Were the weather cold or rainy spiders would not venture forth. Were the wind high its violence would greatly interfere with their excursions. Were the air perfectly still it would be impossible for them to mount above the earth. But the conditions being favorable, as they generally are in the halcyon days of our American autumn, immense numbers of spiders, but particularly the young, may be found upon all manner of elevated objects—blades of grass, weeds, bushes, fences, and what not—essaying an aeronautic flight.

Origin of Showers.

In many, and I would venture to say in the great majority of cases, before a successful ascent is accomplished many unsuccessful attempts are made. A spider will assume the proper position and spin out a long thread. For various reasons, which we are not able to explain, it fails to mount aloft. The thread floats in the air until it is whipped off by the breeze. One, two, or a dozen attempts of this sort produce as many floating filaments. These while waving to and fro in the eddying air are sometimes tangled together before they are loosened. Others, again, are united in the air after release. If now we think of the unnumbered myriads of young spiders who are abroad at this season, all moved by the common impulse to fly away from their present site, and all making the unsuccessful efforts described, we can imagine the enormous quantity of loose filaments of gossamer threads which would thus be set afloat within a short period of time.

Trial Threads.

These, no doubt, ascend to a certain height, at which they become more or less united into a loose, flocculent mass, and from which, in the cool of the evening, or on the cessation of the air currents, they slowly descend, and add to the quantity already fluttering from all points of the herbage on the surface.

[1] "Researches in Zoology," by John Blackwall, F. L. S., second edition, London, 1873, page 258, sq.

This is a natural, and undoubtedly is the true, explanation of gossamer showers. The theories which have attributed them to electrical phenomena, or to the shooting out of threads from the spinnerets by the physical power of spiders before their ascent, must be dismissed as having no foundation in fact. They are really no more worthy of credit than the popular superstition that these fleeing cobwebs are—

> "Caused by the autumnal sun,
> That boils the dew that on the earth doth lie."

The French naturalist Mr. Virey made certain observations and experiments which led him to conclude that spiders "swim in the air" by approximating their limbs and striking the air as birds or insects do their wings. Moving the feet with incredible agility, they are able by means of the vibration to propel themselves through the atmosphere.[1] In this bold but fanciful conjecture, as Blackwall properly terms it, Mr. Virey was anticipated by Dr. Lister. "Certainly this is a rope dancer," he writes, "and itself effects its ascent and sailing. For, by means of its legs, closely applied to each other, it balances itself, as it were, and promotes and directs its course no otherwise than as if Nature had furnished it with wings or oars."[2]

Notwithstanding the importance which such names give to the supposition, it is thoroughly unworthy of belief. The only movement which I have ever perceived on the part of spiders is a momentary adjustment of their bodies, so as to swing them between the two floating rays of threads that constitute their balloon; and, also, to spin the little foot basket or support for their feet, which I have heretofore described. Otherwise they appear to remain perfectly quiet until they reach the ground and escape from their aeronautic threads.

Electricity.

It is hardly worth while to more than mention the theory of Murray that the ballooning ascents of spiders are caused by electricity.[3] The theory was much mooted at one time, and had some worthy names to endorse it. It is, of course, not impossible that a material composed of silk, as is the spinningwork of spiders, may be influenced more or less, and in one way or another, by electricity. But as the result of careful, long continued, and wide observation and study I have no hesitation in saying that electricity has nothing (or next to nothing) to do with the ballooning of spiders, and that the ascending and moving currents of air are entirely responsible for aeronautic phenomena.

There appears to be a special tendency on the part of certain species to undertake aeronautic flight, and certain species appear to be destitute of

[1] Bulletin des Sciences Naturelles, October, 1829, page 133. [2] De Araneis, page 85.

[3] John Murray on the Aerial Spider, London Magazine of Natural History, November, 1828, pages 320, 324.

the power, or at least the wish, for such excursions. Among the latter Blackwall[1] ascertained that Tegenaria civilis and Ciniflo atrox are to be reckoned; among the former, the most skillful balloonists observed by him were Thomisus cristatus and Lycosa saccata. The largest individuals of the first named species seen to take aerial journeys measured one-sixth inch between the extreme points of the head and abdomen, one-tenth inch across the broadest part of the abdomen, and weighed about a quarter of a grain. The largest individuals of Lycosa saccata seen floating in the air were of similar weight and dimensions.

Ballooning Species.

IX.

Most readers of general and theological literature possess some knowledge of the position held by Dr. Jonathan Edwards as a philosopher. His work on "The Will" still ranks as one of the greatest books written by an American; but the fact that Jonathan Edwards is entitled to a place among the pioneers of natural history has heretofore been limited to a small number of persons specially interested in science. To that little band it gives particular pleasure to note the recognition of that fact which the last few months have brought. In the first volume of this work I have already alluded to the observations of Master Jonathan Edwards upon spiders, and have credited him with anticipating by at least one hundred and sixty years some of the most interesting observations which I have made and published under the supposition that they were original with myself.[2]

Dr. Jonathan Edwards.

It is proper at this point to call attention to some facts in the aeronautic habits of spiders which this lad made known. Dr. Sereno E. Dwight, the editor of the "Life and Works of Jonathan Edwards," appears to have been the first to publish a letter written by him, when a boy of twelve or thirteen years old, to an English correspondent of his father's, in which letter he describes what he has seen of the habits of "flying spiders." The scientific world was made acquainted with the matter as early as 1832 by the editor of "Silliman's Journal,"[3] who published in full the above named letter as printed by Dr. Dwight.

The January number of the "Andover Review" takes up this subject anew, and in a valuable paper[4] Professor Smyth covers the whole ground of Edwards' studies, and permits us to look into the operations of the young mind while pursuing his remarkable observations and experiments. An unpublished manuscript is therein edited, which appears to have been the original record of the boy's studies, from

Boy Naturalist.

[1] Researches in Zoology, page 275. [2] Volume I., page 69.

[3] American Journal of Sciences and Arts, Vol. XXII., 1832, pages 112, 113.

[4] "The Flying Spider: Observations by Jonathan Edwards when a Boy," Andover Review, 1890, Prof. Egbert C. Smyth.

which record the letter of the English correspondent was probably constructed.

Young Edwards appears to have made a rude division of various tribes of spiders, which, as far as it goes, is accurate, at least sufficiently so for all popular purposes. In a general way this lad as early as A. D. 1716 had hit upon the foundation principle of classification of the distinguished naturalist Latreille, who, just a century later, divided spiders into seven groups, based upon those very habits which young Edwards notes, although, of course, with more careful characterization.[1]

Edwards had found that on a dewy morning towards the end of August or beginning of September one has the best opportunity to study field spider webs. He had further discovered that spider webs which are ordinarily unobserved may readily be brought into view by putting one's self into such position that the rays of the sun shall fall upon them against some opaque body.

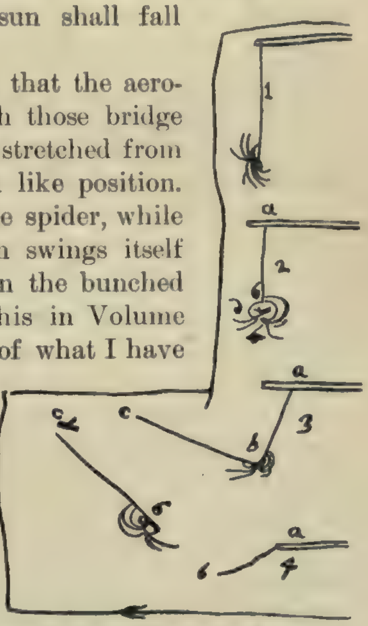


Fig. 281. Edwards' Ballooning Spiders. 1, dropping from twig; 2, swinging from line; 3, sending out threads, b c; 4, a, abandoned thread; c b, spider in flight.

Once more, the boy naturalist had discovered that the aeronautic habit of spiders is closely associated with those bridge lines which are continually observed in summer stretched from tree to tree across roads, between fences, and in like position.

Again, he appears to have discovered that the spider, while engaged in casting out these bridge lines, often swings itself in a little basket of lines held between the bunched feet. I have particularly alluded to this in Volume I., page 69, when speaking of the use of what I have called the swinging foot basket, a habit of which I had supposed that I was the original discoverer. The drawing in Volume I., Fig. 65, was taken from what I supposed to be an accurate fac simile in "Silliman's Journal;" but, in point of fact, Edwards' drawings, as given by Professor Smyth, are far more accurate than those, particularly in the outline of the spider's body and legs, and I therefore reproduce them here, after the drawings in the "Andover Review."

Swinging Foot Basket.

Again, Edwards defined correctly the manner in which the spider's thread is formed. He could make no studies of the interior structure of the animal. It was reserved for the age of the microscope to do this, but this boy of thirteen years old reasoned that the spinning stuff must be contained in liquid form within certain appropriate organs in the abdomen, from which it is expressed, escaping from the spinnerets as a liquid, and immediately hardening by contact

A Prediction.

[1] See Cuvier's "Le Regne Animal," edition 1817, Paris.

with the air. I quote his language: "Seeing that the web while it is in the Spider, is a certain cloudy liquor with which that Great bottle tail of theirs is filld which immediately upon its being Exposed to the Air turns to A Dry substance, and Exceedingly Rarifies and extends it self" . . . . "Now if it be a liquor it is hard to Conceive how they should let out a fine Even thread without Expelling a little Drop at the End of it but none such Can be Discerned, but there is no need of this."

Young Edwards also perceived that the spider had no direction of its frail aerial vessel after it had once embarked, but was compelled to go at the will of the wind, and to disembark and settle wherever its balloon might find an entanglement. He correctly discerned and explained the theory of equilibrium by which the spider navigates the air. This is his explanation: "If there be not web more than enough Just to Counterbalance the gravity of the Spider the spider together with the web will hang in equilibrio neither ascending nor Descending otherwise than as the air moves but if there is so much web that its Greater Rarity Shall more than Equal the Greater Density they will ascend till the Air is so thin that the Spider and web together are Just of an equal weight with so much air." This statement substantially expresses the opinion of all students at the present day.[1]

Prof. Silliman's Tribute.

This review of the studies in natural history of the boy Edwards will suffice to justify the language used nearly sixty years ago by Prof. Benjamin Silliman, one of the most eminent of America's men of science: "The observations recorded by him present a very curious and interesting proof of philosophic attention in a boy of twelve years, and evince that the rudiments of his great mind were even at that immature age more than beginning to be developed." Even with the more perfect light of the present there will be found few to question the further words of the same distinguished authority, that "had he devoted himself to physical science, he might have added another Newton to the extraordinary age in which he commenced his career; for his star was just rising as Newton's was going down."[2]

---

[1] See a paper by the author on "Jonathan Edwards as a Naturalist," in Presbyterian and Reformed Review, July, 1890.

[2] American Journal of Sciences and Arts, 1832, page 110.

PART IV.—THE SENSES OF SPIDERS AND THEIR RELATIONS TO HABIT.

CHAPTER X.

THE SENSES OF SPIDERS, AND THEIR ORGANS.

I.

Spiders' Eyes.

A SPIDER'S eye is a globose object or capsule, lined internally with pigment and having the outer surface transparent and convex, constituting the cornea or corneal lens. Behind the lens is the optic chamber, filled with a semiliquid and lined on the hinder part with the retina, which receives and reverses any image, as in the human eye.

The eye of a spider corresponds with the ocellus of insects, and speaking generally, the ocellus may be regarded as consisting, first, of a lens, forming part of the general body covering; second, of a layer of transparent cells; third, of a retina or second layer of deeper lying cells, each of which bears a rod in front, while their inner ends pass into the filaments of the optic nerve; fourth, of the pigment. From the convexity of the lens it would have a short focus, and the comparatively small number of rods would give but an imperfect image, except of very near objects. Though these eyes agree so far with ours, there is an essential difference between them. It will at once be seen that the pigment is differently placed, being in front of the rods, while in the vertebrate eye it is behind them. Again, the position of the rods themselves is reversed in the two cases.[1]

Ocellus.

In details, the structure of fully formed ocelli presents many differences; and it is remarkable that in some species this is the case even with the eyes of the same individual, as in those of the well known English Orbweaver, Epeira diademata. (Fig. 282). The figure, which is taken from the admirable work of Grenacher,[2] represents a section through the front (A) and hinder (B) dorsal eyes. In this case the eye B would receive more light and the image therefore would be brighter, but on the other hand the image would be pictured in greater detail by the eye, A.

[1] Sir John Lubbock, "On the Senses, Instincts, and Intelligence of Animals," page 147.

[2] H. Grenacher, "Untersuchungen über das Sehorgan der Arthropoden," Göttingen, 1879. I have made the cut from Lubbock's book.

Fig. 283 is a drawing of a section through an anterior median eye of Agalena nævia eight days after hatching multiplied about three hundred and fifty times. The retinal portion has not reached its full development, but on the whole in this stage the essential features of the eye are established.[1]

Structure of Eyes.

It will be seen that in this species, according to Locy, the eye consists, first, of the lens, which a few days after hatching assumes the form of the cuticular lens of the adult; second, the vitreous body, which is the magnified portion of the hypodermis, with which it has never ceased to be continuous; third, of the hypodermis; and, finally, of the retina, consisting of the first or inverted layer of optic invagination, and the second or non inverted layer of optic invagination.

Speaking roughly, the eyes of spiders and ocelli of insects may be said to see as our eyes do; that is to say, the lens throws on the retina an image, which is perceived by the fine terminations of the optic nerve.

From the nature of the external integument, the eyes of spiders would seem to be fixed in one direction. Yet microscopic examination of them when alive appeared to satisfy Mr. Campbell[2] that spiders not only have an adjusting power over the lenses, but that they also can move the eye itself within the cavity covered by the transparent cuticle. This appeared to the author to be the only way to account for the frequent changes of color, as well as of the form and position of the color, which take place in spiders' eyes, and which resemble that of a moving liquid globule. This opinion seems to me unfounded.

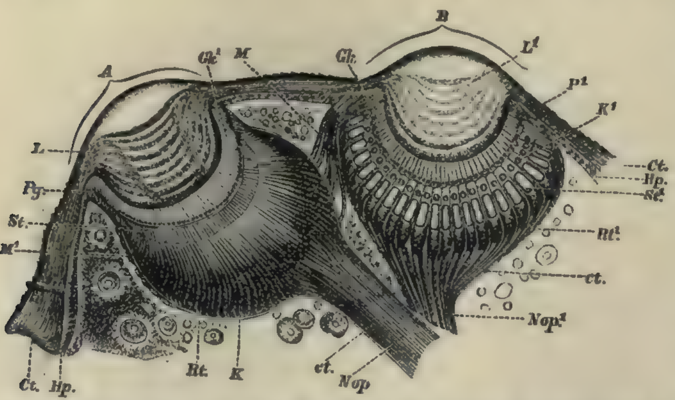


FIG. 282. Long section through the front (A) and hinder (B) dorsal eyes of Epeira diademata. (After Grenacher.) A, anterior eye; B, posterior eye; Hp, hypoderm; Ct, cuticle; ct, boundary membrane; K, nuclei of the cells of the retina; M, muscular fibres; M, M¹, cross sections of ditto; St, rods; Pg, P¹, pigment cells; L, lens; Gk, vitreous body; Kt, crystalline cones; Rt, retina; Nop, optic nerve.

II.

How far Orbweavers may be guided by sight in making their webs, and how far by touch, is an open question. The organs of sight do not seem to be as highly organized in these and other Sedentary spiders as in the Wanderers.

[1] William A. Locy, Observations on the Development of Agalena nævia, Bulletin Mus. Compar. Zool. Harv. Coll., Vol. XII., No. 3, plate x., Fig. 69.

[2] Observations on Spiders, page 42.

Professor Wilder, when studying the habits of Nephila plumipes,[1] came to the conclusion that spiders of that species cannot see anything at all, whether near or remote. I do not accept the conclusion, but give some facts on which it was based. The spiders paid no attention to an object put close to them, nor to the quiet movements of any one about them. An individual would often rush by an insect entangled in her net, if it chanced to cease its struggles before she had accurately determined its position; she would then slowly return to the centre of the web, and wait until another vibration indicated the whereabouts of the insect. A fly offered upon the point of a needle would not be noticed until it began to buzz, when it would be seized at once. Nephila, however, always prefers the light, and constructs her large orbs where the sun can reach them. The young manifest the same instinct, and in confinement seek the sunny side of a glass vessel.

Quality of Vision.

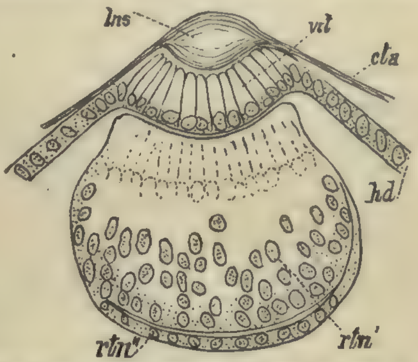


FIG. 283. Sagittal section through an anterior median eye, eight days after hatching; the retinal portion has not yet reached its full development. × about 350. lns, lens; vit, "vitreous body;" cta, cuticula; hd, hypodermis; rtn', first (inverted) layer of optic invagination; rtn", second (non inverted) layer. (After Locy.)

Orbs Made in the Dark.

In order to test the ability of the Furrow spider to work upon her web without the aid of daylight, I secluded one within a large cell with a sliding glass door. She soon spun an orbweb across the cell as close to the glass door and as far toward the light as could well be. Fortunately not a line of the snare was attached to the glass itself, so that I could draw it back and forth at will. I next cut away the lower foundation line, broke up the entire lower part of the web, and the box was then completely darkened. Next day, when the covers and screens were removed, the web was found thoroughly mended, every part being so neatly and accurately repaired that it was scarcely possible to determine which was the patchwork and which the original snare. Even if we admit that some particle of light may have entered the cell, the sense of touch in this case must have been the chief reliance.

Cocooning in the Dark.

In other experiments the spider's sight, in so far as that sense can be apprehended by human experience, could have had no part in directing her work. I have repeatedly confined female Orbweavers, Epeira strix, sclopetaria, insularis, domiciliorum, and triaranea, Acrosoma rugosa, and others, in paper boxes absolutely impervious to light, and opening them the next day have found eggs deposited

[1] Proceed. Boston Soc. Nat. Hist., Vol. X., page 208.

upon the inside, sealed, covered, and swathed within the characteristic cocoon, and all done as accurately as though the creature had wrought under the most satisfactory conditions. Readers who have followed the methods of cocoon weaving as detailed in the preceding chapters will be able to appreciate the acuteness and accuracy of that sense of touch, and whatever other faculty may be associated therewith, by which such an industry was wrought, and share the wonder that it could have been done in total darkness. Like facts are true of other tribes than Orbweavers, particularly Tubeweavers and Saltigrades, with which I have experimented.

The fact that spiders are able to spin their cocoons not only in the dark, but without apparent organs of vision, is demonstrated by the case of the well known cave spider, Anthrobia mammouthia. Professor Packard found this species in Mammoth Cave, and was fortunate enough to collect a cocoon belonging to it. This, of course, shows that the delicate work required in constructing this object can be wrought by touch alone. So also the cavern Linyphians, although having eyes, dwell in total darkness and weave snares and cocoons.

Sighting Prey.

I have often found the peculiar tubular nest of the Saltigrades spun within boxes in which they had been captured. These spiders have, perhaps, the most perfect organs of vision of any of the order. Yet they are able to do quite as good weaving in the dark as in the light. No one who has watched them stalking prey during the day could well fail to conclude that they are guided by a tolerably accurate sense of sight. Their rapid and marked change of manner when prey is "sighted," the mode of approach, like the action of a cat creeping upon a bird, the peculiar behavior displayed when the final spring is made, are not to be accounted for on any theory other than a keen sense of sight. So also with Citigrades. I have seen young Dolomedes sexpunctatus leap from the side of a box and catch a fly "on the wing," and return to its perch by the rebound of its dragline. Such an act not only shows ability to see, but also some faculty to estimate distance, unless we suppose it to have been a chance shot.

In Laterigrades similar action may be observed. Like Saltigrades, they are arboreal in their habits, and crouch for prey and steal upon it. One of our largest indigenous Laterigrades, the Huntsman spider (Heterapoda venatoria), received from Florida and kept in captivity, permitted a large fly placed in her cell to run between the legs, fly into the face, alight on the back, without any attempt to capture it. In the course of time, however, the fly lit on the side of the box a short distance in advance of the Huntsman. She perceived it, crouched, slowly moved her limbs, stealthily and by almost imperceptible advances approached, then swiftly shot forth her claws and secured her victim. The behavior was quite similar to that shown under kindred conditions by animals with well organized sight.

Rev. Mr. Pickard-Cambridge[1] records that he has more than once seen an English Orbweaver, Meta segmentata, drop from her web upon an insect which it had espied on the ground a little way below it, and ascend again with its prize by means of the line drawn from its spinnerets in the descent. This is certainly a remarkable degree of keensightedness for an Orbweaver, one, by the way, that habitually affects a shadowed habitation.

Night Habits.

Many species of Orbweavers are found upon their snares during daytime in normal posture for capturing prey. They seem to have little cessation of activity in the hours of light, nor does there appear to be special increase of activity during evening. Other species, as the Furrow spider, quite habitually exclude themselves from the orb during the day and hide in the vicinity until the approach of evening, when they come forth and take position at the hub of the orb. With most species this is the time when such work will be done. As the light begins to diminish over the landscape an increased activity may be observed throughout a large part of spider world, and everywhere individuals may be seen flying tentative filaments, restlessly pioneering the neighboring shrubbery, running foundation lines, weaving webs, swathing, trussing, eating insects. Something of the same sort may be seen in the early morning, when snares broken by the night's work are renewed or replaced.

III.

Color of Eyes.

I am not prepared, as yet, to say whether a comparison of the species which show morning activity with those which display activity at night would justify a separation into nocturnal and diurnal spiders. Certainly the line would not be a rigid one; but there is some ground to suppose that there are occasional tendencies to this side or that, more or less decided. There is probably a difference in this respect among the several eyes of any one spider; some are undoubtedly organized to receive more light than others, while some receive the image pictured in greater detail. (Fig. 282.) We may therefore attribute different powers of vision to the different eyes. The eyes of spiders vary both in shape and color in the same individual. Some are pearly white; others yellowish, amber, dark gray, or black. Some Saltigrades have eyes that shine like precious stones, reflecting various brilliant hues, as the emerald, the amethyst, the opal—which may be due, in part at least, to reflection from the brilliantly colored mandibles. These hues, according to M. Simon, indicate different powers of vision and qualities of service. Quoting favorably a remark of Dr. Vinson, he would divide a spider's eyes into "diurnal" and "nocturnal." The diurnal eyes are brilliant,

[1] Spiders of Dorset, Vol. II., page 241.

transparent, and seem to have a pupil and iris; the nocturnal are, on the contrary, dull and opaque.[1]

Lebert expresses the same opinion,[2] adding further that those which are most convex and brightly colored, serve to see during daylight, and the others, which are flatter and colorless, serve during the dusk. It occurred to me to test this theory by making such division on the basis of habit, as above referred to, and observe whether the spiders which incline to nocturnal habits have the nocturnal or white eyes, and vice versa. Such a comparison, extended to a few species, shows the following results:—

Night Eyes and Day Eyes.

Among our indigenous Orbweavers, those whose night habits are most pronounced, or whose ordinary habitat is dark or shaded places, proved to have light colored eyes. For example, I rarely find Epeira strix upon her web in daytime; she comes out for prey in the early evening or twilight, and remains quite persistently throughout the day in her nest of curled leaf or in some convenient den. The eyes of this species have the entire rear row and the side eyes of the front row a light gray color. The middle front eyes are of the same color, but a darker shade. Meta menardii, which persistently inhabits shaded places, and which I have found in caves in central Pennsylvania, has all its eyes a light pearl or gray color. The specimens of this species examined were found in Sinking Spring Cave quite distant from the mouth. The Ray spider I have always found in ravines or well shaded spots under the cover of ledges or foliage. Its eyes are all a light pearl, the middle front eyes having a little darker shade.

Turning to other tribes I found, for example, that the Medicinal spider (Tegenaria medicinalis) has all its eyes yellow, with the exception of the small midfront pair, which are dark with a marginal ring of light color. Its dwelling place is habitually cellars and dark corners. I have often found it living quite in the shade.

Clubiona palens, which lives within a silken tube and is frequently found underneath stones, has pearly white eyes, the middle front being a slightly darker shade. The eyes of Agalena nævia are all a uniform brilliant yellow (amber), rather darker than Tegenaria medicinalis. This spider inhabits a tube which expands into a sheeted web. She keeps habitually on guard within the mouth of her tube, but sallies forth at all hours of the day after the prey which drops or alights upon her web. She evidently possesses good day sight. So far, therefore, one might say that the conjecture that the white eyes are used for seeing in the dark, are nocturnal eyes, in fact, is corroborated.

But a further examination introduces facts which are in serious conflict with the theory. For example, Argiope cophinaria lives persistently in the

[1] Simon, Histoire Naturelle des Araignees, page 35.

[2] Die Spinnen der Schweiz, page 6, quoted by Lubbock, "On Ants, Bees, and Wasps," Linn. Soc. Jour., Vol. XX., 125.

PLATE IV

COLORS OF [illegible] COCOONS.

[illegible] OPHINARIA; 2, EPEIRA [illegible]; 4, 5, 6, COCOONS AND FEMALE [illegible] ARGENTEOLA; 14, [illegible] 8, COCOON AND FEMALE OF [illegible]ACANTHA; 9, NATURAL [illegible] CLOSA BIFURCA; 11, FEMALE, [illegible] ENLARGED; 12, DORSAL [illegible] NATURAL SIZE.

[illegible] part. Edw Sheppard Lith. & Del.

[illegible] are on the contrary, dull and opaque.[1]

[illegible] the same opinion,[2] adding further that those which are [illegible] and brightly colored, [illegible] during daylight, and the [illegible] the dusk. It occurred to me to test this theory by making such division on the basis of habit, [illegible] to, and [illegible] the spiders which incline to nocturnal habits have the [illegible] eyes, and vice versa. Such a comparison, extended to a few species, gave the following results:—

Night Eyes and Day Eyes.

Among our indigenous [illegible] whose night habits are most pronounced, or whose [illegible] dark or shaded places, proved to have light [illegible]. For example I rarely find Epeira strix upon her [illegible] she comes out for prey in the early evening or twilight, and [illegible] quite persistently throughout the day in her [illegible] or in some convenient den. The [illegible] the entire rear row and the side eyes of the front row a light gray color. The middle front eyes are of the same color but a [illegible]. Meta menardii, which persistently inhabits shaded places and [illegible] in caves in central Pennsylvania, has all [illegible] color. The specimens of this species [illegible] Spring Cave quite distant from the mouth. [illegible] found in ravines or well shaded spots [illegible]. Its eyes are all a light pearl, the middle front eyes having a little darker shade.

[illegible] I found, for example, that the Medicinal spider ([illegible]) has all [illegible], with the exception of the [illegible] a marginal ring of light color. [illegible] and dark corners. I have often found it living [illegible] in the shade.

[illegible] a silken tube and is frequently [illegible] eyes, the middle front being a [illegible]. The [illegible] are all a uniform brilliant [illegible]. This spider [illegible]. She keeps habitually [illegible] at all hours of the day [illegible]. She evidently [illegible] one might say that the [illegible] in the dark, are nocturnal eyes, in [illegible].

But a further [illegible] conflict with the theory. [illegible] in the

[1] [illegible]

[2] [illegible] "Ants, Bees, and Wasps," Linn. Soc. Jour., Vol. XX., [illegible]

COLORS OF SPIDERS AND THEIR COCOONS.

1, Argiope cophinaria; 2, Epeira insularis; 3, Epeira domiciliorum; 4, 5, 6, Cocoons and female of Argiope argenteola; 14, Male of same; 15, Male abdomen; 7, 8, Cocoon and female of Gasteracantha; 9, Natural size of female; 10, Cocoon string of Cyclosa bifurca; 11, Female, side view, enlarged; 12, Dorsal view, enlarged; 13, Natural size.

Auth-Del. in part

Edw. Sheppard, Lith. & Del.

light. I have always found it hanging on the central shield of its web in broad daylight and at all hours of the day. Its eyes are a light yellow color. The same is true of Argiope argyraspis. Acrosoma rugosa I have always found upon its web in daytime. This is a wood loving species, but commonly spins its web in open places. Its eyes are light gray, the middle front pair having a little darker shade. Epeira labyrinthea is also a diurnal spider, selecting, as a rule, a position upon branches stripped of foliage or dead limbs. Its rear eyes are light colored, pearl gray or a delicate amber, but those of the front row are black. Epeira insularis habitually occupies its nest of sewed leaves during the daytime and often at night also, but it takes prey quite freely during all hours of the day. Its eyes are all light colored. Two gravid specimens of this species which I examined had eyes decidedly lighter than other specimens, and the question occurred to me whether it might not be that the color of the eyes is affected during the period of gestation. I had not sufficient specimens, however, to follow this inquiry, which, perhaps, is not worthy of further attention.

The eyes of Linyphia weyerii, which I have examined from several specimens received from Luray Cave, are of light color, the two central eyes being white. The latter is a marked variation from the general condition of this pair of eyes, which appear to be darker, as a rule, in all terrestial species, and to be obliterated in some cavern fauna.

European Species.

I submitted a few European species to a similar examination.[1] Tetragnatha extensa (Russia) has the side eyes a yellowish brown, the side rear eyes of lighter hue than the side front. The midrear eyes are dark yellow, and the midfront eyes are darkest of all. Epeira sclopetaria (Ireland) has the side eyes light colored, the rear eyes being lightest. The midrear eyes are a dark yellow, and the midfront darkest of all. Epeira sclopetaria of Russia is colored in the same way. Epeira quadrata (Russia) has the side rear eyes light colored, the side front eyes a little darker hue, and the front eyes tolerably dark. Epeira diademata (Russia) has the rear eyes brownish yellow, the front eyes a darker hue of yellow, and the front side eyes a darker yellow, and the midfront eyes darkest of all, almost black.

None of the above species can be classified as nocturnal in their habits, although all of them, of course, are able to capture prey at night. Tetragnatha extensa and Epeira sclopetaria are continually seen upon their webs in broad daylight. Epeira quadrata and Epeira diademata belong to nesting species, having habits similar to our Epeira insularis and trifolium. They live in dome shaped tents, roofed and walled by clustered leaves or by a single rolled leaf. Their faces are towards the opening, looking upon

[1] The Russian species were received from Mr. Waldemar Wagner, of Moscow, and the British species were collected partly by myself and partly by Mr. Thomas Workman, of Belfast.

their webs, which are usually spun in well illumined places. They may be regarded as diurnal in their habits quite as much as nocturnal.

Of Epeira cornuta I examined specimens from Moscow (Russia) and Ireland. The side eyes are an amber yellow of a rather dark hue. The middle eyes are still darker; the midfront ones the darkest of all. The side rear eyes have the lightest hue. This species resembles our Epeira strix in its habits, and is much inclined to live in dark places, and for the most part retires to its cell or den, or some secluded retreat, during the day, showing its greatest activity at night. It is not exclusively a nocturnal species, but approaches nearly that habit.

Epeira umbratica.

Of Epeira umbratica I examined two species captured by me upon the outer basaltic columns of Fingal's Cave and one from England. The side eyes are amber yellow, of a darkish hue. The midrear eyes have a little darker color, and the midfront darker still. In the English specimens the colors were similar, but a little darker, the midrear eyes being quite dark and the midfront almost black. This species, as is well known, is nearest a nocturnal species of all the Orbweavers of Europe. It quite frequently seeks shaded places, although this is not its exclusive habit. The webs of the Fingal's Cave spiders were exposed to the light, although the individuals were hidden within a little recess of the rock. I have seen numbers of the webs of these species on the grounds of Tatton Hall, near Manchester, the estate of Lord Edgerton, swung between the railings of a rustic bridge, shaded only by foliage.

These two spiders present the strongest testimony in contradiction of the theory that the white eyes are most useful to those species that are nocturnal in habit. Judging by their habits, their eyes should have been the lightest of any Orbweavers of Europe, but the contrary appears to be the case. I am not able to solve such contradictory facts. Quite at the opposite extreme, and in line with the general tendency, are the eyes of cavern fauna. The eyes of Linyphia weyerii, which I have examined from several specimens received from Luray Cave, are all light colored, the two central eyes being white.

The above facts appear to point to the conclusion that eyes of a light color are better suited for seeing in the dark, but that dark colored eyes are not necessarily especially valuable to the species having diurnal habits. In short, there does not appear to be a corresponding difference between the nocturnal and diurnal habits of spiders, and the supposed nocturnal and diurnal eyes, sufficiently marked to justify a division on that basis.

Most Persistent Eyes.

An examination of the above facts also shows that there is a quite persistent tendency on the part of the side eyes to be lighter in color than the middle eyes; and, of the side eyes, the rear ones are generally the brightest. It also appears that the middle group of eyes tend to be darker colored, and, of these, the front pair are darkest of all.

On the theory that the dark colored eyes are of the greatest advantage in the light, and the light colored eyes most valuable in the dark, one would expect that in the case of cave species the eyes first to disappear would be the middle ones, and those longest to persist the side ones; the rear eyes longest of all. I was anxious to test this theory, but unfortunately had but a scant amount of material to do it. However, the few facts at hand are valuable for comparison, and are quite in harmony with the above inference.

Pavesi has observed[1] that while the species of Nesticus possess normally eight eyes, in a cave dwelling species, Nesticus speluncarum, there are only four, the four middle eyes being atrophied. This suggests that the four central eyes serve especially in daylight.

The above observation of Pavesi corresponds substantially with Emerton's studies of the spider fauna of some of the large caverns of America.[2] Out of six species of Lineweavers described, five show some unusual condition of the eyes. Three species have the front middle pair very small; one has all the eyes small and colorless, with the front middle pair wanting in the males and some females; and one species is entirely without eyes. The complete obliteration of all the front middle pair in some specimens, and the partial atrophy of the same eyes in others, would seem to indicate that the organs so situated are of most benefit in full sunlight, or, at all events, that sunlight is more necessary to their preservation than the others.

FIG. 285.

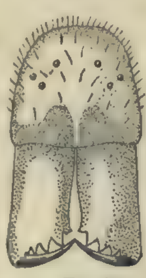


FIG. 284.

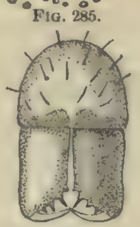


FIG. 286.

FIG. 284. Face of Linyphia inserta, with two eyes wanting. FIG. 285. Eyes of another individual, same species, all present. FIG. 286. Face of Anthrobia mammouthi, with eyes atrophied.

Several figures are here presented, made from Emerton's drawings,[3] which will illustrate the progressive atrophy of the eyes in the case of some of the spider fauna of the caverns of Kentucky and Virginia. Fig. 286 shows the face of a female Anthrobia mammouthia, from which the eyes have been entirely obliterated. Fig. 285 is a drawing of the eyes of a female Linyphia inserta from Fountain Cave. Here the middle eyes of the front row are extremely small, but, nevertheless, are quite manifest. In contrast with this is Fig. 284, which represents the head and mandibles of a male of the same species (Linyphia inserta), from which the middle front eyes have entirely disappeared. The absence of this or any pair of eyes, so far as my knowledge extends, is in no case a sexual characteristic, so that the disappearance of these eyes, if we suppose the figures to have been drawn correctly, can only be attributed

[1] Sopra una nuova specie de Ragni appartenente alle collezioni dei Museo Civico di Genova, Ann. Mus. Civ., 1873, page 344.

[2] Notes on Spiders from Caves, Am. Naturalist, Vol. IX., page 278.

[3] Op. cit., plate i., Figs. 5, 18, 21.

to the gradual progress of the atrophy, or to one of those natural freaks which occasionally occur with spiders as well as other living things.

Occasional irregularities in the number of eyes are not wholly due to causes which produce the atrophy of those organs. For example, Blackwall[1] records that an adult female Epeira inclinata captured in August was entirely destitute of the left intermediate eye of the posterior row, and the right intermediate eye of the same row was not the usual size. In another adult female taken in the autumn of the same year the right intermediate eye of the posterior row had not one-eighth of the usual size, being merely rudimentary. This spider abounds in many parts of Great Britain and Ireland, and seems to prefer districts which are well wooded, but otherwise has no habits which would account for such irregularities. It is simply an abnormal state of the eyes, resulting from some morbid condition.

Concerning Linyphia inserta, drawings of whose eyes are shown at Figs. 284 and 285, Emerton says that the eyes are small and colorless and separated from each other. The front middle pair are very small, hardly larger than the circles around the base of the hair by which they are surrounded, and only distinguished from them by wanting the dark ring which surrounds the hair circles. In five females from Fountain Cave all the eyes are present. (Fig. 285.) In one female one eye of the front middle pair is wanting. In three males from the same cave both front middle eyes are wanting, as in Fig. 284. In one male only one of the front middle pair is wanting. In four females and one male from Bat Cave, Carter County, Kentucky, the front middle eyes are wanting.[2] This irregularity in the number of the eyes indicates with little doubt the fact that the influence of environment has been strongly felt in producing a greater or less atrophy of these organs of sight.

IV.

Sensitive to Light.

That spiders have accurate perception of the direction and intensity of light, one may easily determine by experiments with the young. A great number of such experiments I have made, but will content myself with an illustration or two which fully typify the universal tendency. A brood of young Zillas heretofore described (Volume I., page 143) habitually placed themselves upon the illuminated side of their common web. This position during the day looked toward a bay window a few feet from the table on which the colony was settled, and at night was on the opposite side and toward the lamp on my desk. In the morning, if the day were bright so that the sunlight streamed in at the bay window, the colony invariably migrated to that side. If the day were dull, inasmuch as a side window shed some light over the table,

[1] Spiders Gt. Bt. & Ir., page 355. [2] Op. cit., page 280.

the movement was not so decided. At night the direction was reversed, and the migration set toward the library lights, and the colony settled as near them as possible.

This behavior was so often and uniformly observed that the conclusion was quite satisfactory, but I nevertheless made a series of experiments which fully confirmed it. For example, one evening I found the brood massed at two points (a and b, Fig. 287) on either side of a toy wooden column, hanging in a dim light which fell from a lamp that previously had been turned down. An oil lamp giving a bright light was now lit, and so placed (beyond the point c) that one cluster (at a) was in shadow, the other (at b) faintly illuminated. In twenty minutes twelve individuals had passed over from the partly shaded spot (b) to the illuminated point (c), and about half the group in the shadow (at a)

a b c

Fig. 287. Experiment to show the perception of light by young spiders. The group in shade were all transferred to the shelf by lighting the lamp thereon.

had crossed to the better light at b. The lamp was then removed to the opposite side of the table, reversing the conditions of light, casting c in the shadow, b partly in the shade, and throwing full light upon a. Instantly a movement began among the spiders now in the dark at c, who turned and ran rapidly along the lines communicating with the column. In less than two minutes only four of the twelve remained; one of these soon followed, and shortly the other three. In the meanwhile the shaded group at b was being broken up by an active transfer to the illuminated section at a.

Another experiment gave the following results: I captured a female Epeira sclopetaria at Atlantic City and placed her within a box to cocoon. May 26th, a cocoon was formed in the angle of the box, over which was placed a triangular piece of sheeted spinningwork attached at the three

margins to the sides and bottom of the box. (Fig. 288.) This formed the cocoon tent, whose dimensions were two inches on the floor and along the sides. June 13th, a small cluster of yellowish white spiderlings appeared at the bottom of the cocoon, showing that the young had already hatched and found their way outside within the intervening eighteen days. They had then the appearance of having been hatched a day or two.

During the ensuing week they gradually darkened in color and were joined by their fellow broodlings, who gathered in a semicircle around the upper edge of the cocoon on the box. Here they remained six days upon the top of a case of drawers near an open window. While reading on the evening of June 19th by the light of an argand burner, I glanced upward and observed that the lamp was covered with web lines that fringed the bottom of the porcelain shade and metal stand. Upon these lines forty or fifty spiderlings hung, in the full blaze of light. They had evidently just issued from the cocoon tent, and had been carried by the wind along a bookcase and across the desk to the lamp, a total distance of fourteen feet. A bridge line four feet long was strung from the bookcase to the lamp, along which the brood had clambered, attracted undoubtedly by the light. There was no reason why they should have sought that particular spot, and many reasons why they should have gone elsewhere, but the light dominated their action. (See Volume I., Fig. 141.)

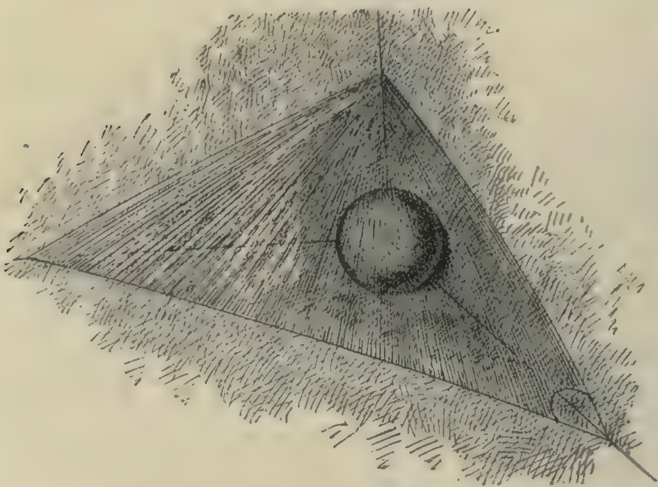


FIG. 288. Cocoon tent of Epeira sclopetaria.

A portion of these I removed to a table, where, during the night, they set up a cobweb commons of the kind heretofore described, and remained grouped thereon until next morning. Then they and nearly all their fellows were dispersed by the breeze when the windows were opened. It thus appeared that exposure to and the force of the wind determined the fact of a quick and wide distribution of spiderlings immediately after egress. In the case of the other broods that were protected from the effects of strong winds, the young remained within a limited space for two or three weeks. Most of them gradually disappeared by aeronautic flight, mounting in that way to the ceiling and walls; some of them spun small orbs in the vicinity, and some remained upon the common web to the end.

V.

The vision of spiders is evidently limited in extent, although it remains to be determined what that extent may be. Prof. Auguste Forel, so widely known for his distinguished studies of ants, records in a paper on the "Senses of Insects," that if a cocoon be removed from a ground spider (Lycosa) to the distance of two or three inches, she will hunt about for it and have great difficulty in finding it. He states, moreover, that jumping spiders (Saltigrades) cannot perceive their prey at a distance greater than two or three inches.[1]

Limited Vision.

Professor Peckham, as the result of his experiments, concludes that spiders, at least the Lycosids, even when they see their cocoons, are not able to recognize them except through the medium of the sense of touch.[2]

But, on the other hand, the Peckhams' observations make it plain that Saltigrades can see objects at a distance of at least ten inches. They frequently saw them stalk their prey at a distance of five inches. They repeatedly held Astia vittata on one finger and allowed it to jump to a finger of the other hand, gradually increasing the distance up to eight inches. As the distance increased, the spider paused a longer time before springing, gathering its legs together to make a good "ready."

I have repeatedly verified this experiment with an adult female of Phidippus morsitans. Holding the spider upon a box in which she had been taken, I approached a finger within an inch of her face, until her attention was evidently attracted. Presently she leaped the space, alighting upon the finger. I then restored her to her position upon the box, and by manipulation again tempted her to escape by vaulting twice the distance. By gradually increasing the space, she finally jumped a distance of from three and a half to four inches. Her whole action showed that she had seen the object before her, had discerned the fact of an intervening space, had carefully measured the distance, and then vaulted, successfully reaching the object. As usual on such occasions, she always kept herself secure by a dragline attachment to the box from which she jumped.

Twice the Peckhams saw a male Astia vittata chasing a female upon a table covered with jars, bags, and boxes. The female would leap rapidly from one object to another, or would dart over the edge of a book or box so as to be out of sight. In this position she would remain quiet for a few moments, and then, creeping to the edge, would peer over to see if the male were still pursuing her. If he happened to be hidden, she would seem to go to him even when ten or twelve inches away, and would quickly draw back. But in case he was hidden behind some object, she would hurry off, seeming to

Good Sight in Saltigrades.

[1] Sensationes des Insectes, I. Recueil Zoologique Suisse, Tome IV., No. 1, pages 18, 19.

[2] Mental Powers of Spiders, pages 401, 402.

think she had a good chance to escape. The male in the meantime frequently lost sight of the female. He would then mount to the top of the box or jar upon which he found himself, and, raising his head, would take a comprehensive view of surrounding objects. Here he would remain until he caught sight of the female, which he often did at a distance of at least ten inches, when he would at once leap rapidly after her.[1]

These observations certainly show a well developed power of vision, sufficient at least for all purposes of the active life led by these wandering Saltigrades. They confirm the opinion elsewhere expressed in this work (Volume I., page 19), that individuals of this tribe possess more highly developed vision than those of any others. One might almost infer this from the appearance of their eyes, the seeming expression which rests upon their faces, and the general intelligence that marks their demeanor and movements.

Lubbock's Experiments.

Sir John Lubbock appears to have tested the experiment made by the Peckhams upon sight of spiders. Lycosa saccata, a familiar European species, was selected for his observations. A female from whom an egg sac was removed was placed upon a table, about which she ran for a while as though looking for her eggs. When she became still, the cocoon was placed about two inches in front of her. She evidently did not see it. It was gradually pushed towards her, but she took no notice until it nearly touched her, when she eagerly seized it.

The cocoon was again removed, put in the middle of the table, from which all other objects had been taken. The spider wandered about, sometimes passed close to the egg sac, but took no notice of it. She spent an hour and fifty minutes in this aimless wandering before she found the cocoon, and then apparently by accident. A third time it was removed, placed upon the table as before, and an hour was spent in wandering before it was discovered. The experiment was tried with other individuals, and with the same results. Sir John's conclusion is that "it certainly appeared as if they could not see more than half an inch before them; in fact, scarcely further than the tips of their feet."[2]

It is impossible, however, to admit the explanation which the learned author has made of this inability promptly to recognize the cocoon. "It must be remembered," he says, "that the sac is spun from the spinnerets, and that the Lycosid perhaps had never seen the bag of eggs." On the contrary, the manner in which the Lycosid prepares her round cocoon, as it has been quite fully shown and described by myself,[3] compels the conclusion that the mother Lycosa has perceived her cocoon both by the touch of sense and sight from the beginning of its fabrication to the

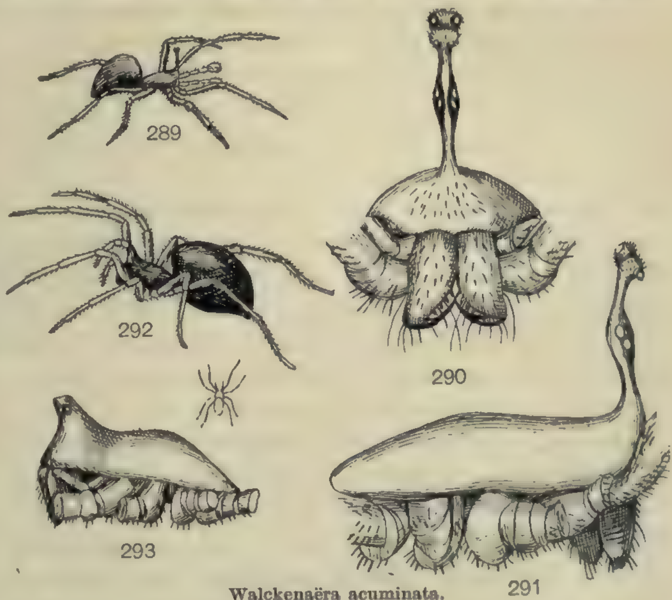
[1] Mental Powers of Spiders, page 402.
[2] Senses, Instincts, and Intelligence of Animals, 1888, page 179.
[3] See Chapter V., page 144.

time when, having deposited the eggs within the little circular patch, she rolls the cover around them into a ball, and then attaches the ball to her spinnerets. This is undoubtedly the universal method with spiders that carry about their egg sacs. The cocoon covering is first spun upon some surface, the eggs enclosed, the ball prepared, and the last act is attaching it to the spinnerets.

Of course, during this process, a spider whose eyesight is so good that it can perceive its prey at a distance of several inches, must of necessity have seen its cocoon. It would be impossible for us to reach any other conclusion. The confusion in maternal recognition and selection of her offspring cannot, therefore, be accounted for by defective sight.

Eye Turrets.

Among the Theridioid spiders is a large group of species which Blackwall has placed under the genus Walckenaëra, which present some remarkable peculiarities in the location of the eyes. These are distributed on the anterior part of the cephalothorax, which sometimes in females and usually in males is remarkably elevated. The drawings here presented (Figs. 289–293) are taken from Blackwall's descriptions of Walckenaëra acuminata,[1] and represent one of the most remarkable of these turret like developments of the caput for the reception of eyes.[2] The length of the female (Fig. 292) is about one-seventh of an inch. The sexes are similar in color, but the male (Fig. 289) is smaller than the female, and the anterior prominence of its cephalothorax is much more elongated and slender, measuring about one-twentieth of an inch in length. This eye turret is elevated vertically and dilated near the middle and at the apex (see Figs. 290, 291), the latter dilatation being separated by a transverse groove into a superior and inferior segment, both of which are rough, with short, strong hairs. On



Walckenaëra acuminata.

FIG. 289. Male. FIG. 290. Eye turret of male, greatly enlarged; front view. FIG. 291. The same, side view. FIG. 292. Female. FIG. 293. Same, side view of cephalothorax, with outline showing natural size. (After Blackwall.)

[1] Spiders Gt. Br. & Ir., pl. xx., Fig. 203.

[2] See also Mr. E. Simon's Arachnides de France, Vol. V., part III., page 820.

these enlargements the eyes are seated. Both sexes of this curiously constructed spider were taken in England in October under stones and on rails.[1]

It is to be observed that the greatest prominence of the eye turret of Acuminata belongs to the male, and this appears to be the rule with similarly constructed species. What can be the cause or the use of this? One would think that such a remarkable development must be intended to serve the spider some special advantage in making its way around its natural site. But until we know something more in detail of the habits of the species we can only venture a suggestion. The probability is that all these small Theridioid spiders, like many of the minute species dwelling in the United States, spend their life upon or near the surface of the earth, where they weave their loose webs of lines around the bases and among the roots of grasses. It may be taken for granted that the male, in his amorous search after the female during the period of courtship, would find such an eye turret advantageous in detecting the home web and person of his mate amidst such an entangling environment. At least, no other advantage can be suggested for this strange exaggeration of the tubercles on the eye space.

Use of Eye Turrets.

A difficulty which at once arises, is the fact that so many other species having like habits and location show no peculiarity of a like kind, and appear to have no need therefor. Great numbers of species have eyes placed upon tubercles or slightly elevated parts of the caput, usually of a rectangular or quadrangular shape. In some Epeiroids these tubercles are quite pronounced, and many of the genera are sharply distinguished thereby. In many more genera, and indeed it may be said in almost all, the eye or ocellus proper is quite commonly raised upon or within a little cup of black chitinous formation, which thus slightly elevates it above the surface of the face. As far as I know, there are not many eyes that appear to be set immediately into the eye space without this enclosing cup.

Eye Tubercles and Rows

Among Saltigrades and Citigrades one pair of eyes is commonly placed at considerable distance behind the others, giving in this way an additional advantage to the species by the seeming ability to observe, to some extent, objects lying behind it. The breaking up of the eyes into rows, generally two, but sometimes three, may serve the same useful purpose. This whole subject is an interesting one, but the facts in my possession are so few that I can do little more than open it for the consideration of future students.

VI.

In considering the sense of smell in spiders two questions require attention. In the first place do spiders possess this sense at all, and, if so,

[1] Blackwall, idem., page 290.

to what extent? And, in the second place, where are the olfactory organs located? The conclusion which I had reached, as the result of experiments and observations of my own, is that spiders have little sense of smell, although they are in some way affected by certain odors. I have long entertained the opinion that the sense of smell in spiders, like that of hearing, abides entirely in the delicate hairs which constitute the covering and armature of the creature. I have thought that in some way the nervous system receives through these organs or appendages impressions that may be considered analogous to hearing and smelling in the higher animals; but, further, that both these senses are in an extremely rudimentary condition.

The Sense of Smell.

These conclusions are substantially confirmed by the experiments recorded by Professor and Mrs. Peckham, which were carefully performed and continued through a number of examples large enough to justify a conclusion. Their method was to place a rod dipped in various essential oils, cologne, and several kinds of perfumes, close to the various parts of the spiders, and note the effect. The results were carefully tested in all cases by first presenting a clean rod. Among the essential oils used were oil of peppermint, of lavender, of cedar, of cloves, and of wintergreen. The first experiments made were upon some tame Attidæ that had taken up their abode with them. These were fearless little creatures, ready to jump upon the finger, catch the gnats that were offered them, or drink from a spoon. They showed the same facility in smelling that they exhibited in seeing, and were quick to respond to any test of their sense of smell. The most common effect produced by an odor was that it caused the spiders to raise their fore legs and palps, which sometimes they also moved up and down. In one case great excitement was caused by the approximation of peppermint. In several cases the spiders, after indicating that they noticed the scent, moved away from it.

The Peckhams' Experiments

Effects of Odors.

With Orbweavers the effect of the various perfumes was to cause an upward jerk of the abdomen and a movement of the legs. Sometimes the tips of the legs were rubbed between the palps and the falces. The result of two hundred and twenty experiments may be summed up as follows: Three species, Epeira hortorum, Dolomedes tenebrosus, Herpyllus ecclesiasticus, did not respond to the test. In all other cases it was evident that the scent was perceived by the spiders, although it may be noted that among spiders of the same species great differences of degree exist in their sensitiveness to odors. The spiders exhibited their sensitiveness to the various perfumes by movements of the legs, palps, and abdomen; by shaking their webs; by running away; by seizing the rod which had been dipped into the scent, enswathing it as they would insects; in the case of the Attidæ, by approaching the testing rod with the first leg and palps held erect, but whether in the way of attacking it, or, as it sometimes

seemed, because the smell was pleasant to them, the observers could not determine.[1]

As to the olfactory organs, the experiments would indicate that they are distributed more or less over the entire surface of the body, especially at the tips of the feet and at the apex of the abdomen, but that they probably are more highly developed in the fore part of the body and in the organs immediately surrounding the face. In order to test the value of the palps as olfactory organs, those parts were dissected from two females of Argiope cophinaria. The resulting tests indicated that the araneads had suffered no apparent loss of sensitiveness. In one case the application of the oil of lavender at the front of the body caused the spider instantly to contract her legs and rub the tips thereof, one at a time, upon the falces. The other spiders responded to heliotrope and Chinese bouquet by quickly jerking the abdomen and rubbing the tips of the legs over the falces.

Olfactory Organs. Location.

VII.

A number of experiments, prolonged through several years, have been made with a view to determine the extent to which spiders hear, and the location of the auditory organs. I have found myself continually thwarted, or at least confused, by doubts lest the various responses made were caused by independent movements of the air, which, operating on the delicate body armature, of course produced sensation and excitement. I made many experiments upon the tarantula "Leidy," which I had in my keeping for more than five years, and whose life I have elsewhere recorded.[2] These experiments were made with tuning forks, with several kinds of musical instruments, and by sounds of all degrees of sharpness and dullness made by the human voice and various sonorous objects.

Sense of Hearing.

Once I had nearly concluded that the great creature was immensely excited by my flute. Certain tones, when the instrument was brought close to the vessel in which the tarantula was confined, caused her at once to rear upon her hind legs in that rampant attitude which this creature assumes when about to strike its prey. During one experiment, however, something occurred which induced me to drop my flute and make a light puff of air with my mouth over the edge of the glass cage, so that the wind thus produced would be reflected against the animal. At once she assumed the rampant position precisely as before. Repeating this, I found that it was simply the motion of the air over the mouth hole of the flute, which was carried into the cage, that had agitated the tarantula. In other

[1] Mental Powers of Spiders.

[2] Proceedings Acad. Nat. Sci., Phila., 1887, page 369, sq. "Prolonged Life in Invertebrates: Notes on the Age and Habits of the American Tarantula."

words, when I blew upon her, the action of the wind excited her, and caused her to rear upon her hind legs as though some enemy were approaching or some victim coming within reach.

This will illustrate some of the difficulties in the way toward a just verdict. Of course, all sound is produced by vibrations of the air; but it seems possible that the movements produced by tuning forks and other instruments, sounded, as they must be, in so close proximity to the spider, may and probably do mechanically agitate the hairs upon the body, and thus effect the sense of touch alone, producing an excitement which I have often observed and sometimes attributed to hearing. The difficulty has been to separate between these two sensations and decide whether my experiments had not simply excited the spider by touch. My conclusion, as the result of independent observations, is that if spiders have any sense of hearing proper, that sense is distributed, like the sense of smell, over the entire body; and, further, that it can scarcely be distinguished from the sense of touch as it is known to us. No doubt, however, the aranead has some of the advantages within its limited sphere that auditory organs proper give to higher animals.

Organs of Hearing.

On this point the Peckhams also made a number of experiments, with some interesting results, as follows: Certain spiders indicate that they hear a vibrating tuning fork, by characteristic movements of the legs; others by signs of alarm, dropping from the web and keeping out of sight for a longer or shorter time. One spider, at least, Cyclosa caudata, when subjected to frequent approximations of a tuning fork, seemed to become gradually accustomed to the sensation, and, instead of dropping from her web as at first, remained immovable and apparently undisturbed. One of the most interesting points developed is that orbmaking spiders appear to be most sensitive to the vibrations of the tuning fork. All these responded promptly, being evidently alarmed by the sound.

On the contrary, spiders that make no webs gave not the slightest heed to the sound. Among those species that proved unresponsive were two Tubeweavers (Herpyllus), several Lycosids, and the familiar Dolomedes tenebrosus. Professor Peckham suggests that this difference may be partially explained by difference in the feeding habits of the two groups, an explanation which leaves much to be explained. May we venture to suppose that, in the case of the Orbweavers, the particular effect produced by the vibrations of the tuning fork upon the spider hanging on her web, or upon the delicate filaments of the web itself, is very much the same as that produced by the rapidly vibrating wings of an insect when humming around the snare or when struggling within it? Certainly Orbweavers are dependent upon some such agitation, especially of the web, for the intelligence that their snares have succeeded in trapping a victim. On the other hand, we know that Lycosids, for example, which stalk their prey in the open field, instead of ensnaring them

Effects of Sounds.

upon silken nets, are chiefly dependent upon sight for knowledge of their victim's presence and power to secure it.

A few experiments were made to determine where the organ of hearing is located, which, as far as they go, seem to confirm my own opinion as expressed above, that the auditory apparatus is but little specialized, and is distributed over a considerable portion of the epidermis. The removal of the palps appeared to make no difference in the power of individuals to respond to the vibrations of the fork. So also the removal of the first pair of legs seemed to leave the auditory organs intact, at least made no impairment of power to respond to sound.

Tuning Fork Experiments

I will now describe two of my own experiments, as illustrative of the method pursued and the grounds for reaching my conclusion. An adult female Domicile spider, hanging in the centre of her orb, was tested by an "A" tuning fork. The fork in rapid vibration was moved all around her, gradually approaching until the instrument was within a few millimetres of her person. All parts of the body were thus tested and no signs of excitement appeared. The fork was then touched to the top of the web, when Domicile immediately showed signs of excitement, acting precisely as if an insect were entangled at that point. She turned herself in the direction of the fork, grasped the radii leading outward to the point of contact, pulled upon them in the usual way as though testing the strength or entanglement of the supposed insect, and then gradually approached the point of agitation. I withdrew the fork, and, as the spider came up to the margin of the web where the instrument had been, she turned around, made several motions as though examining the strands, spun out a few lines, and went back to her hub, dragging a thread after her.

A Disgusted Spider.

The fork was then placed at the bottom of the web, then at the sides, and so successively to various points on the circumference of the orb. The same action substantially resulted, the spider always going to the spot where the fork was vibrating against the lines of her web. Finally, I suffered the fork to remain as the spider approached. She touched it with her fore feet; at once showed tokens of surprise, indeed of some stronger emotion; she seemed to be expressing the feeling, "I have been fooled;" turned her back upon the fork, shot out a thread from her spinnerets, and scampered away to the hub, where she curled herself up, drawing her legs toward her face until the knees projected above the head, exhibiting what I cannot express by another phrase than tokens of disgust.

I then laid the vibrating fork upon the outer lines, but Domicile would not respond. I revolved the fork around the hub, close to her, as at the beginning of the experiment. This time, instead of remaining motionless, she waved her fore feet back and forward, as though she had observed the vibration and were feeling the situation. After a few moments'

interval I again tried the fork to the sides of the web. This time Domicile was again deceived, and turned towards the point of agitation as in previous cases. She had evidently forgotten her former experience in the brief intervening space.

Communication by Touch.

The conclusion which I draw from such an experiment is that the spider was affected by the vibratory motions of the fork, communicated through the taut elastic line to the hairs and spines of the feet. The sense of touch was the only means of communicating the agitation, and no other indications of the spider having heard the sounds of the fork were here shown than appear in the capture of an insect under well known and ordinary circumstances. Certainly the theory has never been advanced, and could not be maintained, that the spider hears the motion of an entangled insect's wings and runs to secure the victim at such a signal. In such case it is manifest that the spider feels the action of the struggling captive as it is communicated over the vibrating radii to her feet, which grasp them at the centre of her snare. If this be so, it seems to me equally manifest that the same sense was brought to bear in determining the position of the tuning fork in the above and like experiments.

I may venture to give the record of another experiment with the tuning fork, which was also wrought upon a Domicile spider. The vibrating fork was placed near her as she sat upon the hub, and moved around her four times, the spider showing no symptoms of perceiving the vibrations. The fork was approached within a few millimetres of the hind legs, whereupon she showed excitement. This was again repeated a number of times, the spider showing no signs. I quote the notes: "The vibrating fork is next touched to a radius on one side of the web. The spider turns and runs out towards the point of contact. After one minute's interval the orb was touched on the opposite side. Domicile leaves the hub, runs out a little ways towards the fork, hangs upon the radial line, waves one fore foot around through an open space torn by the rain just below the hub, then returns to the hub.

"One minute interval. The fork is applied to a radius at the top of the web. Domicile makes same demonstrations as before. One minute interval. The fork is applied within a half inch of the spider's face as she hangs upon the hub. She stretches out one fore leg as on guard. One minute interval. The experiment is repeated. The fore legs are both thrown out quickly, violently, as though to grasp something. After one minute the experiment is repeated three times. The first two are unnoticed. At the third application Domicile shoots out her fore legs. After the same interval the fork is tried at one side and at the top of the web several times. No response. It is then placed upon the web at the other side. The spider runs towards the fork. Various trials are made at the same and other points, and all fail to elicit a response."

The result of this experiment, as in the case above detailed, and indeed in all other cases tried, is the conclusion that the symptoms of hearing, as they have ordinarily been described, seem to appear in the spider only when the vibration of the sound instrument is communicated along the line of her web to the hairs which form the armature of her body.

Conclusion from Experiments.

I can reach no other conclusion from the experiments so admirably portrayed by Mr. Peckham.[1] His experiments upon Orbweavers enabled him to get results which, to his mind, indicated the sense of hearing. That the vibrations produced a state of excitement is true, but the question is, what was the mediate cause of that excitement? Did it result from hearing a sound, or was it simply caused by feeling a vibration similar to that made by an insect captured or hovering near? Mr. Peckham's experiments indeed seem to me clearly to indicate the conclusion which I myself have reached.

He used the tuning fork upon a half dozen species taken from different groups of spiders, making ten or twelve trials on each one. No individual gave the least intimation of hearing anything. These unresponsive species belong to the genus Herpyllus among the Tubeweavers, and the genera Pardosa, Piratica, Lycosa, and Dolomedes among the Citigrades. None of these spiders, so far as known, ever capture their prey by means of webs—a fact which struck Professor Peckham. It seemed to him "remarkable that while all the Epeïroids responded promptly, being evidently alarmed by the sound of the tuning fork, the spiders that make no web, on the contrary, gave not the slightest heed to the sound. This may perhaps be partially explained by the difference in the feeding habits of the two groups."

Does this explain anything? The difference here indicated certainly lies in this, that the excitement of the Epeïroids was produced by the agitation of the hairs upon their feet, and that agitation was awakened by vibrations of the fork along the lines of the web. That the web is affected by these vibrations I thoroughly satisfied myself by experiment. For example, a vibrating fork, when approximated to the broad, zigzag ribbon upon the orb of Argiope, would cause it to sway back and forth as though agitated by the motion of the air, which, beating upon it, alternately repulsed and attracted it.

It would indeed be a remarkable fact were it to be established that those spiders which, like the Lycosids, are dependent upon keenness of the senses for their success in capturing prey, should prove to be destitute of the valuable sense of hearing; while the webmaking spiders, who are so little dependent upon the sense of hearing, and are enabled to accomplish the most important functions of life by the sense of touch alone,

[1] Mental Powers of Spiders, pages 396, 397.

should be found to possess hearing in a degree of acuteness. It is not often that one finds a contradiction like this in natural history, viz., that those animals that most need a certain organism or sense have none, while those which are in least need are highly sensitive.

Mr. Boys' Experiments.

The experiments of Mr. C. V. Boys[1] would really lead to the same conclusion. He notes that after a spider has been dropped from its web by bringing a tuning fork near it, if the fork is made to touch any part of the web the spider is aware of the fact, and climbs the thread and reaches the fork with marvelous rapidity. Mr. Peckham observes and records a similar fact in the case of Epeira strix and Epeira labyrinthea.[2] How shall we account for these actions? It appears to me clear that when the fork was placed near the animal its vibrations agitated the hairs upon the body and the spinningwork immediately under and around, just as a large insect hovering near in the same position would have done. The spider, therefore, did in the case of the tuning fork what it would almost certainly have done in the case of the insect—it dropped from its hub as a measure of defense.

In fact, a spider seated upon its hub is ordinarily at a decided disadvantage when an insect enemy, such as a wasp, approaches near it. Its best defense, therefore, is to get out of the way. But it is quite a different thing when its enemy appears at any viscid part of the web and by the agitation thereof gives indications that it is captured. This is a signal which the spider understands to mean, in almost every case, that its victim is ensnared and it can approach it with comparative safety. For this reason the spider that would run from an insect or a supposed insect that seemed to threaten it, would run towards the same when it appeared to be captured and harmless. In these experiments, therefore, I see simply different manifestations of the same sensation of touch under different exciting causes.

VIII.

Sensitiveness to Music.

In connection with these observations upon the auditory powers of spiders, one must at least glance at the numerous stories about, and prevalent beliefs in, the sensitiveness of spiders to music. There is such a discrepancy between belief in this commendable trait and the general contempt and disfavor with which araneads are regarded, that one might incline to think there is good grounds for the tradition, since it would hardly have arisen under the circumstances without some basis of truth. Certain it is, the opinion is quite ancient and is widely distributed. Nor are there lacking incidents of seeming historic verity to be cited in confirmation thereof. It may be of value, it will at least be interesting, to quote a few of these.

[1] "Nature," XXIII., pages 149, 150. [2] Op. cit., page 411.

The anonymous author of an ancient history of music records the following examples among others which tend to illustrate the effect of harmonious sounds upon the lower creation.[1] An officer of a Navarre (French) regiment was committed to prison for having spoken too freely of M. de Louvois. In order to brighten his prison life he sent for his lute. He was astonished, after four days, to see that when he played, the spiders would descend from their webs in his cell and form in a circle around him in order to listen.

On the first occasion he was so greatly surprised that he remained perfectly motionless, when, having ceased to play, all the spiders retired quietly into their dens. This strange assemblage caused the officer to fall into a muse upon the accounts related by the ancients of Orpheus, Arion, and Amphion. He assured the author of the Histoire, who appears to have received his account at first hand, that he remained six days without again playing, an abstinence which was caused in part by his astonishment, and perhaps more especially by the natural aversion he had for this kind of "insects." However, he began anew to give a concert to these animals, who seemed to come every day in greater numbers, as though they had invited others, so that in the course of time he found a hundred gathered about him.

Attracted by a Lute.

But this sort of society in such multitude proving in the end undesirable, Monsieur the Captain got a cat from his jailer. This animal he would shut up in a cage when he wished the presence of his aranead admirers; on the contrary, when he would dismiss them, he let the cat loose. The particular actions of pussy are not described, but the narrator alluded to them as "making a kind of comedy that alleviated his imprisonment."

The author of this history from which I quote long doubted the truth of the above story, but declares that he was confirmed therein by subsequently hearing a gentleman of position, merit, and probity, who played very skillfully upon several instruments, relating an incident of the same tenor. This person said that he once went into his chamber to refresh himself after a walk, and took up a violin to amuse himself with music until supper time, a light being placed upon the table before him. He had not played a quarter of an hour before he saw several spiders descend from the ceiling, who came and arranged themselves round about the table to hear him play. He was greatly surprised at such a demonstration, but did not interrupt the music, having the curiosity to see the end of so singular an occurrence. The spiders remained on the table very attentively until some one entered to call the musician to supper, when he ceased to play. Thereupon, as he informed the author, the spiders remounted to their webs, and, very much to his credit be it said,

The Violin.

[1] "Histoire de la Musique et de Ses Effets," edition Paris, 1715. I am indebted to the musical library of Mr. H. C. Wilt, the organist of my church, for references to this book and the work of Sir John Hawkins.

he added that he would suffer no injury to be done them. Subsequently he declared it was a diversion with which he often amused himself and gratified his curiosity.[1]

A somewhat similar incident is associated with the distinguished musical composer Ludwig van Beethoven. According to Schindler, the story, if not originated, was generally spread by a biographical paper on Beethoven by Dr. Christian Müller, of Bremen. The tradition runs that as often as the little Ludwig played his violin in his little room a spider, enamored of the strains, let itself down and sat upon the instrument. When his mother discovered her son's strange companion she killed the spider, whereupon the little fellow broke his violin. Upon this fairy tale Schindler comments: "The great Ludwig could not recall such a fact, as much as this fable amused him. On the contrary, he said that everything, even flies and spiders, would have fled before his terrible scratching."[2] Of course, in view of such statements, not the slightest credence can be given to "this pretty fairy tale of a poet's invention," and it shows how little credit is often due to these popular fancies that associate themselves with distinguished characters.

Beethoven and the Spider.

The well known anecdote of Pelisson, as described by Abbe Olivet, is another example in point. This gentleman was confined in the Bastile during the reign of Louis XIV., and amused himself by feeding a spider, which, from the description, must have been one of a Tubemaking species. The hour of feeding was timed to the rude music played by a Basque, who was the companion of his cell. The spider in time learned to distinguish the sound of the music, and to associate it with the season for its special banquet. This story, with various embellishments, has had a wide circulation and belief, though I believe it is wholly discredited by modern historians.

Pelisson's Spider.

Cowan quotes an account of a certain young ladies' school at Kensington, England, in which an immense species of spider was said to be uncomfortably common. When the young ladies were gathered for their morning and evening worship, and engaged in singing their accustomed hymn, these spiders made their appearance on the floor, as the story goes, or suspended overhead from their webs in the ceiling. The obvious attraction, it was inferred, was the sweet singing by the worshiping young ladies.

Singing and Piano

Walckenaer quoted Gretry as relating in his memoirs that at his country seat a spider would seat itself upon the table of his piano whenever it was played, and would disappear therefrom when one ceased to touch the

[1] Sir John Hawkins' History of Music, Vol. III., page 117, note.

[2] Biographie von Ludwig van Beethoven verfasst von Anton Schindler. Dritte, neu bearbeitete und vermehrte Auflage. Erster Theil, page 3, Münster, 1860. See also Thayer's History: Ludwig van Beethoven, von Alexander Wheelock Thayer. Erster Band, page 112, Berlin, 1866.

keys. He also states, as a fact which had recently come to his attention, that a lady while playing a harp in the midst of her garden perceived a spider fixed in the attitude of attention above her. Presently she transported her instrument to another part of the room, whereupon the spider also changed its position. The lady's curiosity being excited, several similar movements were made, which led her to conclude that the aranead was affected by the sound of the instrument.[1]

Music Box.

Campbell had in confinement a Tegenaria domestica, which at a tune from a music box would open her spinnerets, an act which is common to spiders when expecting food, and go to the centre of her web where she used to be fed. It took some weeks thus to train her, and the first sign of reconciliation to her imprisonment was an angry movement of the falces when he touched her, whereas previously she used to run away.[2] He also speaks of startling spiders some distance off by the banging of a door, and their agitation could not be explained by supposing a current of air; nevertheless it easily might have been explained by the agitation of the door jambs communicated through the wall to the web of the spider.[3] Other examples might be cited, but the above are sufficiently typical, and will answer all my purposes.

A Natural Explanation.

Now, the question naturally arises, what basis of fact is there for such a consensus of belief? Shall we dismiss the matter by simply supposing that all the individuals concerned deliberately drew upon their imagination, or were deceived? There is no reason to doubt a certain part of the facts, at least. It is noticeable that in most of the above accounts the hour at which the spiders appeared was the evening, or just before evening. This is a most natural occurrence. I have sat upon an open porch or verandah, and as the afternoon waned and sunset drew near, have seen spiders descend from the angles, cornices, and crevices of the ceiling and roof, and spin their webs in the open spaces above me. They seemed to hang suspended in the air, without any special purpose, and, indeed, one who did not take pains to watch them would naturally conclude that they were in a position of fixed attention.

Evening Habits and Vibration.

It is customary for spiders, particularly Orbweavers and Lineweavers, who are the ones to which such manners are to be attributed, to descend in this manner and present this attitude as the evening approaches, which is the time for their ordinary activity. To be sure, they do not remain thus long, but proceed to make their snares, yet, in so far, the stories which we have quoted may be considered as substantially true. The persons concerned may have seen the spiders descend at the evening hour and hang in an apparent attitude of attention.

[1] Aptères, Vol. I., page 110.
[2] Observations on Spiders, F. Maule Campbell.
[3] Ibid., page 41.

The question may further be raised, did the music have any effect in promoting this habitual behavior? I would not be willing to affirm it, but it is not improbable. The vibrations of air caused by singing and the sounds of flute or violin might affect spiders, as they rested upon their webs in the angles and corners of the ceiling, to such a degree as to impress them with the idea that insects were near. No doubt there is some similarity in the effects produced by the humming of insect's wings and the vibration of musical instruments. It is not irrational, therefore, to conclude that certain spiders may have been influenced by musical sounds to such a degree as to hasten their habitual action. But, for the most part, as far as our stories are to be regarded as credible, I am inclined to think that habit alone is sufficient to account for the alleged conduct of the spiders.

That they were affected by the music to the degree believed and reported is not credible; though it is perfectly natural that, under the circumstances, the observers should have so believed. Imagination could have gone a far way to supply the details and picture the spiders as gathering around the table or head of the performer in rapt attention to the "concord of sweet sounds." As for the rest, one knows how stories grow—how a spider or two can be multiplied into a dozen, and how a dozen can readily grow into a hundred, and a natural action be involved in mystery or exaggerated into marvel. But, however we dispose of these widely disseminated traditions, one thing is certain, I have never been able, after many experiments and observations, with all sorts of music, good and bad, and with divers instruments, to see the slightest evidence that spiders are in the least sensitive to music.

IX.

Spiders are well provided with the means of feeling the slightest movements of their webs or other objects. On their legs and palps are long, slender, silken hairs, which differ from others in that they are attached to a small disk on the integument.[1]

Auditory Hairs.

It is not my purpose to present anatomical details of the organs through which the sensations analogous to smelling and hearing are conveyed to the nerves of spiders. But somewhat has been written upon the matter, and a reference thereto will be of interest. Dahl has opened the way in a contribution upon the auditory organs of spiders,[2] and this has been freely commented upon by Mr. Waldemar Wagner, of Moscow.[3]

[1] Campbell, Observations on Spiders, Trans. Hertfordshire Nat. His. Soc., Vol. I., 1880, page 40.

[2] Das Gehör- und Geruchorgan des Spinnen, Zool. Anz., 1883.

[3] Des Poils Nommés Auditifs chez les Araignées. Bull. de la Societe Imper. des Naturalistes de Moscou, 1888.

Several illustrations of the types of hairs known as auditory are here reproduced from the latter writer. Their character is well enough explained in the legends of the cuts, but a brief description may be added. The two parts of the hairs are distinguished as the root and the stalk or shaft. By the root is understood that portion which enters the cuticle, and is inserted into an appropriate pit; by the stalk the free part of the hair which extends above the cuticle. The hairs of spiders, both by their structure and their root, appear to be divided into two principal types, perfectly distinct. One sort is distinguished by a root which is much larger than the portion of the stalk immediately above it. In other words, the stalk narrows at its foot to swell out again into a much enlarged root, thickened into the form of a button and inserted into a sac like cavity of the skin. (See Fig. 294.) This is what Wagner denominates a Tactile hair, proper. The roots of the other sorts of hair are ordinarily much smaller, as compared with their stalks, than the type above named. (See Figs. 295 and 297, r, r, compared with Fig. 294, r, r.) The hair pits or follicles enclosing the roots are also more simply constructed.

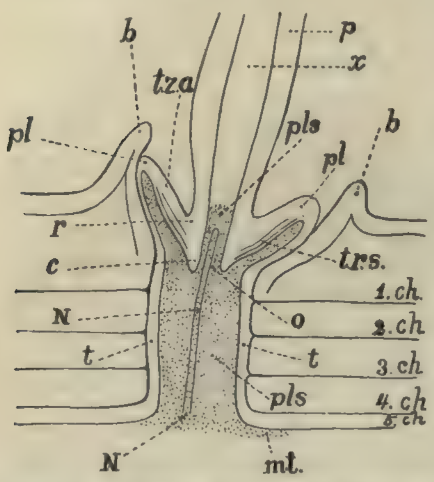


FIG. 294. Transverse section of a Tactile hair in the foot of a spider. (After Wagner.) ch, 1, 2, 3, 4, 5, layers of chitine; mt, the matrix of the hair; t, tube formed by the inferior layer of the cuticle (ch. 5), and filled with plasm, pls; pl, fold formed by the tube (t) at the level of the first layer of the cuticle; t.r.s., inferior part of the basal thickening of the fold; t.r.a., its superior part; r, central part of the radix of the hair; c, papilla; o, orifice of the root by which the plasm passes from the cavity of the tube into the cavity of the hair, x; N, the nerve; p, the stalk of the hair; b, the annular thickening of the superior layer of the cuticle surrounding the root of the thread.

Tactile hairs (poils tactiles) are endowed with extreme sensibility, as is manifest from the fact that the lightest filament of silk can at once be detected by them and communicated to the animal. The other types are simpler in their structure and, perhaps, their function. Dahl does not make any distinction between the hairs of the different types, and names them all auditory; but Wagner distinguishes the hairs into three principal types, the Tactile hair, including one of finer structure (poil tactil fin), the Beaded hair (poil a chapelet), and the Clubshaped hair (poil cucurbitiforme).

The principles that led Dahl to attribute to his auditory hairs this function rests alone upon the fact that the waves of sound set them into motion, which movement is borne along the extremity of the nerves and provokes the sensation of sound.

He appears to attribute the same function to all the types of hairs distinguished by Wagner. In this opinion the latter author cannot agree,

but thinks that the functions of these three types are not identical, since being found upon the same individual, one cannot well admit that three different organs are constructed for the same physiological role. Might they not, however, serve for different degrees of the same function?

Wagner does not doubt that spiders have a delicate sense of hearing, but the objective ground on which he rests it is unreliable. He states it as "a fact known to all biologists," that in order to entice a spider from its nest or den it is only necessary to cause a fly to buzz near it, while an unskillful imitation of the buzzing sound fails to deceive the aranead. On the contrary, even the presence of flies in the web often fails to tempt the spider forth; and I know that unskillful imitations of insects have often drawn them forth; but such imitations I have never confined to sounds. They are only or chiefly successful when the movement is communicated to the threads of the web itself.

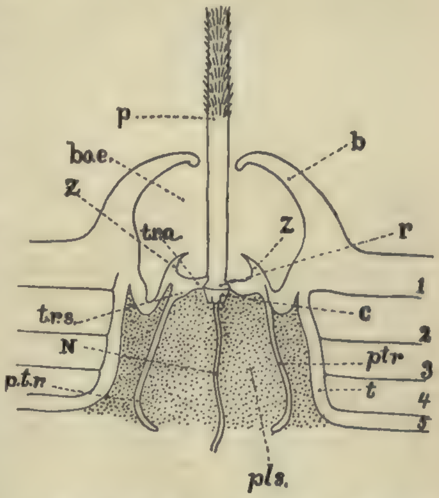


FIG. 295. Section of a Beaded hair. The parts corresponding to those of the Tactile hair are marked by the same letters. z, an eminence around the superior part of the basal thickening of the fold by which the free borders are bent against the stalk of the hair, and form a little external pouch which is situated in front of the large external pouch; bo.e., cavity of the large external pouch; r, root of the hair with its thickening; p.t.r., section of the walls of the external pouch by which the inferior part of the basal thickening of the fold (t.r.s.) is set below; b, wall of the large external pouch, corresponding to the annular elevation of the first layer of chitine in a Tactile hair, b, Fig. 294.

Wagner admits that if the movement of hairs of any type under the influence of sound could be proved, that would suffice to assign to that type the role of an auxiliary auditory organ, at least. But, in fact, it is far from being proved that sound sets the so called auditory hairs into movement. At least his own experiments failed to show this. By the aid of an electric lantern he was able to throw distinctly upon a screen figures of a row of auditory hairs, enlarged to the size of from three to six inches. He had prepared a fine section of that portion of the foot which is provided with auditory hairs, and this had been so placed as to allow free movement. Sounds of various sorts and tones were then produced without having any effect upon the shadows on the screen.

Suspecting that his lack of success might be due to the dryness of his preparation, he replaced it with a foot freshly cut from a living spider. The figures of the hairs were thrown clearly upon the screen, and, again, every effort to cause them to move by the aid of sound waves was unsuccessful. The size of the hairs upon the screen was so considerable that the least vibration would be perceived, and, therefore, he could hardly admit that the failure was the result of defect in his experiment. From the

above facts he concluded, first, that the function of the three types of hair above described cannot be recognized as identical; and, second, that no one of these types can be regarded as an auditory organ.

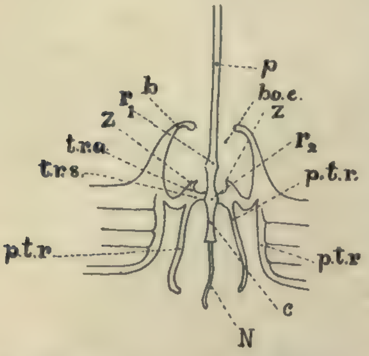


Fig. 296. Section of a fine Tactile hair. p, the stalk of a hair; r, the superior thickening of the root in the cavity of the large external pouch; bo.e., cavity of the large external pouch; r_2, basal thickening of the root at the point of its junction with the basal fold; z, elevation upon the superior part of the basal thickening of the fold by which the free borders are bent against the stalk of the hair and form a little external pouch; p.t.r., section of the walls of the internal pouch, by which the inferior part of the basal thickening of the fold (t.r.s.) is inserted beneath; b, wall of the large external pouch, corresponding to the annular elevation of the first layer of chitine in the Tactile hair. The other parts corresponding to those of the Tactile hair are marked by the same letters.

But, if their function is not identical, their fundamental likeness in anatomical structure gives one a right to suppose that they do have a function more or less analogous. Wherein does that function consist? Mr. Wagner considers that the function of the Tactile hairs ought to be more perfect than that of the other types, because of their more perfect structure, and that, therefore, they should be capable of receiving more delicate excitations than the ordinary Tactile hairs. One use, he thinks, may have been indicated by Dahl, who remarks that the slightest breath of air is able to move the auditory hairs, a fact which may be readily observed; at least, that spiders are always extremely sensitive to the slightest puff of wind made by the human mouth. There may, therefore, be assigned to the auditory hairs the function of transmitting the mechanical movements of the air.

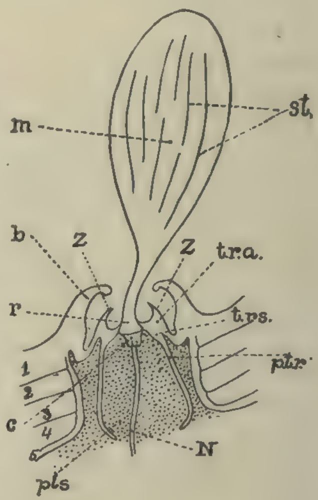


Fig. 297. Section of the root of a Clubshaped hair. m, the clubshaped blade of the hair; st, longitudinal striations of the blade; z, elevation upon the superior part of the basal thickening of the fold by which the free borders are bent against the stalk of the hair and form a little external pouch; r, root of the hair, with its thickening; p.t.r., section of walls of the internal pouch by which the inferior part of the basal thickening of the fold (t.r.s.) is inserted beneath; b, walls of the large external pouch, corresponding to the annular elevation of the first layer of chitine in the Tactile hair. The other parts corresponding to those of the Tactile hair are marked by the same letters.

Wagner again raises the conjecture that the Beaded and Clubshaped hairs may be used to indicate the state of the weather; a conjecture which he bases upon what he supposes to be an accepted fact, namely, that spiders are so sensitive to weather changes as to be able to anticipate them, and, indeed, to prognosticate them by their behavior. That this is a widespread belief I elsewhere indicate (in the chapter on General Habits); but that it is without foundation, I think, I also show; so that Mr. Wagner's suggestion must fall to the ground before the presence of facts of habit.

My own opinion is that all these various types of hairs may be regarded, generally speaking, as Tactile hairs, and that they serve to communicate to the spider the sensations which are included by more highly organized animals in the distinct senses of touch and hearing, and, I might add, of smell.

It seems to me that there can be nothing contrary to this view in the fact of differences in the forms of hairs, if we suppose that the several types may indicate some differentiation in the character of touch sensations communicated by them, so that a spider may be able to distinguish between the agitations of the air caused by ordinary movements of the wind and the impressions of waves of sound, and those sensations which result from touch proper, as the undulatory motion of surfaces on which a spider rests, or the agitation of the web upon which it hangs and the trapping thread to which it holds as it lurks within its den. In other words, there are differences in the sensations produced by the organs of touch, but these have not been so far differentiated as to justify us in distinguishing any of them as organs of hearing.

Mr. Wagner calls attention to facts which may lead up, after wider study, to important conclusions. He says that the Orbweavers (Epeiridæ) and Lineweavers (Therididæ), for example, only possess these hairs upon the tibia and metatarsus; while the Wanderers have them not only more numerously on the tibia and metatarsus, but also upon the tarsus. We perhaps may not accept Mr. Wagner's opinion that the Wanderers are exposed to far greater dangers than the Sedentaries, but certainly there is a difference in the form in which the dangers approach them, as well as in the character of the dangers. The greater number of Tactile hairs on the legs of Wanderers may perhaps be associated with the fact that they do not rest upon a web, but come in contact with the ground and the various surfaces on which they lurk for prey. Their feet also are used, at least in some cases, for digging holes in the earth and for other uses which are not habitual to Orbweavers and Lineweavers. Moreover, Sedentary spiders, hanging on their webs by their feet, need a concentration of sense organs in the neighborhood of the claws or tips of the tarsus; and it seems to me that the Sedentaries are well provided in this respect, and are thus able to detect the slightest motion that runs along the lines of their snares when agitated by insects or by raiding enemies. However, we must confess that here we are largely in the region of conjecture, but the manner of life among Wanderers, one would suppose, naturally requires a better physical organization, inasmuch as they are not provided with the habit which constructs trapping instruments for the accession of prey and the defense of their persons. In other words, it may be that the presence of additional sensation hairs upon the Wanderers is a compensation for the lack of industrial facilities.

Mr. Wagner has also found some interesting facts concerning the

development of these Tactile hairs. Immediately after hatching from the eggs, Attus terebratus has none of these organs upon its tarsus or metatarsus, and only one upon the tibia. Lycosa saccata when first hatched has not a single Tactile hair. After the second moult, however, both these species acquire one hair upon the tarsus, two upon the metatarsus, and two upon the tibia. Lycosa saccata when adult has four hairs upon the tarsus, nine of such hairs on the metatarsus, and seven on the tibia. This would seem to indicate that with the development of the spider, and thus with the approach of need for sensation organs, Nature causes those organs to appear. The young spider has no need of food, as it subsists upon the nourishment provided by the mother in the egg. It is not until after its first moult or two that Nature requires it to set up housekeeping for itself, and capture its own prey. This is true of the Sedentaries. The Wanderers, at least some of them, live with the mother until the first moult has been made.

X.

Are Spiders Mute?

Are spiders mute? The question is one of much interest, whether considered from the standpoint of the relation between the sexes, or the number and nature of the senses. The amount of information possessed upon this subject is scarcely sufficient to warrant a decided opinion, but such as I have will be presented.

At the outset, it may be suggested that, reasoning from analogy, we would expect to find in spiders some mode of stridulation. The subkingdom of Arthropoda, to which they belong, has at its head the Insecta, among which are many genera whose species are characterized by their power to stridulate. In illustration of this, any frequenter of our fields and forests will recall the rolling drumming of the harvest fly or cicada, which may be heard in vast and confusing notes when the seventeen year locust, as it is popularly called (Cicada septendecim), makes one of its periodical appearances, and covers the trees with hosts of insects. The cheerful creaking of "the cricket on the hearth," which has passed into our proverbs and poetry, is an example of stridulation. The shrilling of the grasshopper, locust, and field cricket are other well known examples. Professor Wood-Mason has discovered stridulating organs in the Phasmidæ.[1] These were seen in a species of Pterinoxylus, the stridulating organs being fixed partly on the wings and partly on the tegmina, like the Orthopterous Ædipoda described by Scudder.[2]

In these cases it has commonly been regarded, and is probably true, that the stridulating instruments are exclusively possessed by the males, and that the sound is in some way intended as a call to his mate. This

[1] Proceedings London Entomological Society, 1877, page xxix.
[2] American Naturalist, Vol. II., page 113.

fact has long been known, as is evident from the old witticism attributed to the incorrigible Rhodian sensualist Xenarchus, who alludes in the following terms to the cause of that great happiness which was popularly attributed to these insects, and which seemed to the common folk to make them apt images of the gods:—

A Male Love Call.

> "Happy the Cicadas' lives,
> Since they all have voiceless wives!"[1]

The fact here noted is probably true of insects generally, as in most cases females cannot utter sounds, and stridulating organs are limited to males. Yet there are some exceptions which add perplexity as well as interest to the problem. For example, the stridulating organs possessed by the Phasmidæ above alluded to are, according to Professor Wood-Mason, found in the females, thus furnishing a case in which functional stridulating organs are present with that sex. Another example of power to stridulate on the part of female insects is that of Cicada montana.[2]

Exceptions.

Passing to the other extreme of the Arthropods, we find examples of stridulating among Crustaceans and Scorpions. Mr. Darwin, alluding to stridulation among spiders as recorded by Professor Westring, makes the remark that this is the first case known to him, in the ascending scale of the animal kingdom, of sounds emitted for this purpose.[3] But we are now able to embrace other Arthropods among the music making animals belonging to the lower orders.

Mr. J. Sackville Kent discovered sound producing properties in a Crustacean, a species of Spheroma. He was not able to ascertain the exact method in which the sound was produced, nor whether the animal has organs specially adapted for the purpose. On numerous occasions, however, he heard the sound made by this little creature, a Crustacean scarcely one-fourth of an inch long. The animal was confined within a glass jar, of which it was the only occupant, and the noise made was a little sharp tapping sound, produced three or four times consecutively, with intervals of about one second's duration.

Stridulating Crustaceans.

The observer could almost exactly imitate it by striking the side of the jar with the pointed end of a pipette. The character and intensity of the sound produced, associated with the small size of the animal, induced him to believe that it was caused by the sudden flexion and extension of the creature's body.[4]

---

[1] See Cowan's Curious History of Insects, page 250.
[2] See Trans. Lond. Soc., 1877, page xvi.
[3] Descent of Man, Vol. II., American Edition, Chapter IX., page 330.
[4] Nature, November 1st, 1877, page 11. See also Proc. Lond. Ent. Soc., 1877, page xxvii.

On this communication Professor Wood-Mason remarks that the sound producing organs in Crustacea are paired organs, as in Scorpions, Mygalæ, and Phasmidæ; that is to say, organs working independently of each other on each side of the body. They are differently seated or situated in various genera, but in all cases appear to consist of what may be called a scraper and a rasp, and the sound is produced by rubbing together these two organs, which constitute the stridulating apparatus.

Stridulating Apparatus.

Professor Mason has also announced the discovery of stridulating organs in Scorpions. This appeared from the study of the anatomy, but the matter was placed beyond doubt by observations made at Bombay. Two large living scorpions, procured from Hindustani conjurors, were fixed face to face on a light metal table and goaded into fury. At once they commenced to beat the air with their palps, and simultaneously to emit sounds which were distinctly audible, not only to the observer, but also to bystanders. They were heard above the flutter made by the animals in their efforts to get free, and resembled the noise produced by continuously scraping with one's fingers bits of silk fabric or a stiff tooth brush. The stridulating apparatus in this species is developed on each side of the body; the scraper is situated upon the flat outer face of the basal joint of the palp fingers, the rasp on the equally flat and produced inner face of the corresponding joint of the first pair of legs.[1]

Scorpions Stridulate.

It is thus found that from one extreme of the Arthropods, the Insecta, where stridulation is frequent, through the Scorpions, and to the opposite extreme, the Crustaceans, the habit of producing sounds, for whatever purpose, is to be found. We therefore have a strong basis in analogy for the belief that similar organs might be found among the spiders, animals that rank between these extremes.

XI.

In point of fact, such organs have been found. The Swedish naturalist Westring was the first to discover them, and his observations are accessible to the general reader in his valuable work upon Swedish Spiders.[2] He appends this observation to his description of "Theridion serratipes." The abdomen of the male, around the cord by which it is united to the thorax, is armed with a denticulated coat, whose use Westring had often puzzled over. At length he fortunately discovered that this valve is an instrument for stridulation. At the base of the thorax the aranead is armed with transverse, most delicately wrinkled striations, which are applied by the animal for the producing of sound, as among insects. This sound Westring heard when the spider was squeezed slightly; then, either freely or when touched

Westring's Discovery.

[1] Proc. Ent. Soc. Lond., 1877, xviii. [2] Araneæ Svecicæ, page 175.

with the fingers near the apex of the abdomen, he moved his abdomen up and down, and its base or the serrated valve near the base of the thorax was rubbed upon. The female of the species does not possess these organs.[1]

Stridulating Theridioids.

Mr. F. Maule Campbell[2] has taken up these observations of Westring, and in a valuable and interesting paper added much to our information. He made special studies, both of the male and female of Steatoda guttata and Steatoda bipunctata. In the fore extremity of the abdomen he found, in the male of Guttata, that the socket is a complete ring with some strong chitinous spurs on the inside of its external edge (Fig. 299), which is also roughly serrated. That of the female is divided into two parts, the inferior being smallest, while the superior, as in the male, is the deepest. In the female (Fig. 298) there are no spurs. The inner edge, however, is undulated, and in points becomes angulated, while a little below are stiff hairs on small protuberances. The chitinous thoracic extension of the male is marked on its

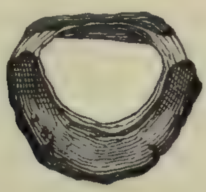


Fig. 298.

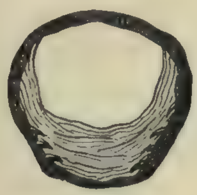


Fig. 299.

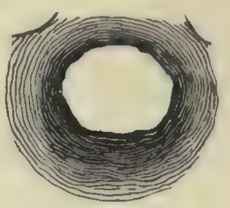


Fig. 300.

The stridulating organs of Steatoda guttata, male and female. (After Campbell.)
Fig. 298. Female; view from above, of chitinous ring or socket attached to abdomen, covering the union with thorax. Fig. 299. The same part of the male. Fig. 300. View from above of chitinous extension of thorax of female.

superior surface with many fine, parallel, transverse grooves, which are absent in the female. (Fig. 300.) In the same position on both sexes are several ridges which are less numerous in the male. Thus, it appears that while it is likely that individuals may vary in details, the female of Steatoda guttata has organs adapted to stridulation, as well as the male.

Mr. Campbell also examined both sexes of Steatoda bipunctata, and found that the socket of the male is much shallower than those of the male and female of Guttata. The inside of the external edge is rough, and the sides are lined with a row of bristles seated on prominences. The only opposing surface is a spinate ridge on the base of the thorax, which

[1] Since this original discovery Westring had heard many males of Theridium and Steatoda stridulating. Among these he mentions Theridium castaneum Clerck, Theridium (Steatoda) bipunctatum (page 185), Theridium hammatum, Theridium albumaculatum (page 186), Theridium (Steatodos) guttatum (page 188).

[2] On Supposed Stridulating Organs of Steatoda guttata and Linyphia tenebricola, Linn. Soc. Jour. Zool., Vol. XV., 1880, page 152.

has no chitinous extension covering the abdominal union. In the female of this species, unlike Guttata, there is no trace of these organs.

How Sounds are Made.

Of course, any sounds which might be produced by the organs thus described, must be occasioned by the flexion and extension of the two principal parts of the body; that is to say, by the drawing back and forward, within the socket, of the cartilaginous pedicle which connects the thorax with the abdomen. But Mr. Campbell has also discovered an apparatus which he ventures to call stridulating, seated on the falces and palps in both sexes of Linyphia tenebrosus.[1] These are of a different structure from those heretofore described. On the outer side of the basal joint of each falx are about twenty parallel transverse chitinous bands, placed so that their inferior edges are free. (Fig. 301.) The effect, when viewed from the front, is that each falx has a distinctly serrated outer edge, which becomes more and more decided towards the base.

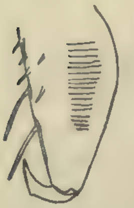


FIG. 301.

FIG. 302.

FIG. 301. Right falx of Linyphia tenebricola, male, viewed obliquely from the right side. FIG. 302. Humeral joint of left palp, showing spines on the inside alone, and at the top the horny plate. (After Campbell.)

The opposing surface is that of the humeral joint of each palpus (Fig. 302), which is marked with a more or less regular series of curved grooves deep enough to give the appearance of serration on its side under a two-third objective. On the under side of this joint, close to its base, is a curved enlargement, and on the top a prominent, horny, somewhat triangular, knob like plate, with a rounded apex. This differs in form, size, elevation, and position from the chitinous prominences usually seen in connection with spines, of which there is one near each side, but of which, in some individuals, it is independent.

The above described organs persist in all adult members of this species; but those on the palps of females are not so highly developed, the chief difference being the size of the enlargement at the base of the third joint. When confined in a glass tube, Mr. Campbell observed that these spiders often move their palps backward and forward, with a slight rotary motion, in such a manner that the horny plate crosses the bands on the falces. But he had been unable, even with the aid of the microphone, to detect sounds in connection with these movements.

Mr. Campbell adds the suggestion that the absence of specialized stridulating organs in most Araneæ does not imply that they are mute. It is a common practice with many to rub the falces against the maxillæ; and were the serrated edge of these latter found in another part of the body, similarly opposed to a hard, toothed, chitinous surface, it is most likely they would be pronounced stridulating organs.[2]

[1] Linyphia terricola Blkw., or Linyphia tennuis Blkw. [2] Op. cit., page 155.

Another account of organs of stridulation in spiders is that observed by Mr. S. E. Peal in the great stridulating Mygale of Assam, and brought to notice by Prof. James Wood-Mason.[1] Mr. Peal's account is that the noise is made by the tarantula when in a state of great excitement, particularly at the presence of some enemy. When thus roused, the spider usually rested on the four posterior legs, raising the other four and shaking them in the air, with the thorax thrown up almost at right angles to the abdomen, and the palps in rapid motion. The noise made is both peculiar and loud. It resembles that made by pouring out small shot upon a plate from a height of a few inches, or perhaps by drawing the back of a knife along the edge of a strong comb. The stridulation was very distinct, and had a ring about it which the observer had never noticed in the stridulation of orthopterous insects, wherein it more closely resembles a whistling sound.

Mygale stridulans.

Professor Wood-Mason, who reported Mr. Peal's statement to the London Entomological Society,[2] remarks that the sound apparatus in Mygale stridulans has been found to consist, first, of a comb composed of a number of highly elastic and indurated, globe shaped, chitinous rods, arranged close together on the inner face of the basal joint of the palp; and, second, of a scraper formed by an irregular row of sharp erect spines on the outer surface of the penultimate joint of the palps. He further states that it is equally developed in both sexes, the first specimen met with by Mr. Peal having been a gigantic female.

In the spiders alluded to by Westring, the stridulating apparatus consists, as we have seen, of a serrated ridge at the base of the abdomen, against which the hard hinder part of the thorax is rubbed, and of this structure not a trace could be detected in the females.

Professor Mason agrees with Mr. Darwin and Professor Westring in feeling almost sure that the stridulation made by these spiders serves as a call to the female. It is manifest, however, that if the sound serve this purpose in the Mygale, it must serve as a mutual call, the apparatus being present in both sexes. Professor Wood-Mason further ventures the suggestion that the sounds are emitted by the spider in self defense; that is, to render itself terrible in the eyes of its enemies; or, it may be from fear. He thinks that they may also be serviceable to the spider in terrifying its prey; and, further, that during its nocturnal rambles in quest of food, it may warn the creatures that it preys upon of its dangerous and deadly nature, as, for example, is the case with the rattles upon the tail of our American rattlesnake.

Uses of Stridulation.

Of course, the presence of stridulating organs, if they be regarded as sound producing organs, naturally infers the presence of auditory organs.

[1] Proc. Asiatic Soc. Beng., 1876, and Ann. Mag. Nat. Hist., 1876.

[2] Transactions, 1877, page 282.

FIG. 303 (upper figure). A Tarantula rampant, just before striking.
FIG. 304 (lower figure). Tarantula in act of striking.

If we suppose that the species of spiders in which the male is provided with stridulating apparatus, possesses it for utility in courtship, and uses it for love calls, as is generally thought is the case with orthopterous insects, then we must also suppose that auditory organs exist, at least in the female spider. In other words, spiders are not deaf; they can hear. It is true that distinct auditory organs have never been found, at least have never been recognized as such, and, if spiders hear, they must hear by means of sense organs widely different from any possessed by animals that have the power of hearing.

If, further, we suppose that those species wherein stridulating organs are possessed in common by male and female, use them to make mutual calls, like the notes of birds or like the sounds uttered by higher vertebrate animals, then we are also to infer the power of hearing in the male as well as in the female.

This much, at least, appears reasonably certain, that the theory that the organs above described are proper organs of stridulation, whose purpose is to produce sounds that will be heard by the opposite sex, is dependent upon the demonstration of the fact that spiders possess organs of hearing. If we are able to affirm the presence of auditory organs in spiders, we may then conclude that the way at least is open for the theory that stridulating organs are common for mutual communication by sound between the sexes. Until this be established, the theory rests upon a very uncertain foundation.

My Mute Mygalidæ

Concerning the observations upon the stridulating Mygale described by Mr. Peal, and announced by Professor Wood-Mason, I would remark that I have kept for many years in succession living species of both males and females of the large Mygalidæ. One of these (Eurypelma hentzii) I had in my possession for a period of nearly six years, and one living at this date has been with me about five years. I have often seen them assume the attitude described by Mr. Peal. When I have tested their appetite for small vertebrates by putting mice into their artificial home, or have given them large insects, as locusts, or when I have teased them with a pencil, or annoyed them in any way, it is their invariable habit to throw themselves into the rampant position which Mr. Peal has described and illustrated. This position I have frequently sketched from various points of view, and from some of these sketches Figs. 303 and 304 have been engraved. But in all these cases I have never heard any other sound than that which I regarded as the clattering of the fangs as they were struck together in the movements of the mandibles under the powerful influence of hunger or fear. No sound that I could at all regard from any other standpoint has it ever been my opportunity to detect. Such negative evidence, of course, amounts to little—amounts to nothing, indeed—in the face of positive testimony. I only state it as serving to qualify any conclusions which we may be disposed

to make as to the actual cause and intention of the sounds which sometimes are heard to issue from spiders in a condition of excitement.

How Tarantula Strikes.

The method of the tarantula in attacking its prey is similar to that of Lycosids and other spiders. It throws itself upon the four hind legs, draws back its cephalothorax to a greater or less degree, according to the nearness of its adversary, raises the two front pairs of legs and the palps, and, holding them well together, throws them backward, opens wide the tremendous fangs and the mandibles, which are held straight out from the face, and then at the proper moment launches itself forward (Fig. 304), striking its adversary with its fore claws and fangs. The stroke will be repeated a number of times with great rapidity, and after each stroke the tarantula falls back into the rampant position above described. (Fig. 303.)

I am hardly able to give serious credence to Professor Mason's theory that the stridulating organs, like the rattles upon a rattlesnake's tail, are intended to give warning to victims. Even if we were to suppose that the large insects and other creatures fed upon by these spiders are able to detect such sounds and recognize their meaning, I cannot think, in the face of my long continued observations of living species in confinement, and the few observations made in the state of Nature, that they do utter sounds sufficiently distinct to cause anything like terror on the part of intended victims. I never saw an insect fed to my tarantulas that showed the least sign of fear or even consciousness of the presence of an enemy.

CHAPTER XI.

COLOR AND THE COLOR SENSE.

THE popular impression that spiders are extremely ugly is deeply seated. Even specialists in other branches of natural history are apt to express surprise when one speaks of high ornamentation among araneads. Butterflies are commonly thought to have special claims to beauty, and without disputing these one may truthfully say that as fair and brilliant colors may be found among the Araneæ as among the Lepidoptera. I suppose the popular impression to the contrary is largely due to the fact that the spiders which frequent our cellars and outhouses, and straggle occasionally inside our homes, belong to the genera whose colors are rather inconspicuous. Possibly, contact with human beings has tended to demoralize these species, and thus disrobe them of colors which once may have made them attractive!

I.

Facts of Spider Colors.

One does not need to go to the tropics for examples of richly colored spiders. Our indigenous Orbweavers furnish species whose coloring may well challenge the admiration of lovers of the beautiful. This will be abundantly illustrated by the plates prepared for Volume III. of this work, but several examples are presented in this volume, as those on Plates I. and IV. Our two indigenous species of Argiope have bright colors, Cophinaria being at once distinguished by her size and prominent black, yellow, and brown markings, and Argyraspis adding to these a metallic white which in earlier stages of her life has a noticeable lustre.

Epeira insularis is well known among familiars of our fields by her attractive yellow and orange colors; and the varied and beautiful robing of the Shamrock spider is well illustrated by the specimens presented in Plate I.

Yet these are far excelled in beauty and brilliancy by the Orchard spider, and the remarkable aranead, Argiope argenteola (Plate IV., Fig. 6), which is found in the southwestern portions of the United States. The genus Acrosoma also presents several species whose attractive coloring makes them worthy of notice in this connection, and Gasteracantha (Plate IV., Fig. 8) is often well decorated.

Many Theridioids also bear beautiful and delicate colors, the varied hues and shades of green, yellow, and brown being particularly noticeable in this group. Some of the genera, as the parasitic species of Argyrodes, are covered with burnished silver. Of these two tribes of Sedentary spiders it may be affirmed that they contain, in all portions of the world, and particularly in tropical countries, examples of as delicate and brilliant coloring as may be found elsewhere in Nature.

Beautiful Spiders.

But the coloring of Orbweavers and Lineweavers is probably even exceeded by that of the Saltigrades, which is as rich as that of hummingbirds or beetles, according to Professor and Mrs. Peckham. The most brilliant family of this tribe, the Attidæ, especially, contains examples of brilliant ornamentation. Of some of these araneads Wallace says that they are noticeable for their immense numbers, variety, and beauty. They frequent foliage and flowers, run about actively in pursuit of small insects, and many of them are so exquisitely colored as to resemble jewels rather than spiders.[1] Elsewhere he speaks of the abundance and variety of the little jumping spiders which abound on flowers and foliage, and are often perfect gems of beauty.[2] Most travelers in South America who have carefully observed aranead life, agree with Bates that the number of spiders ornamented with showy colors is remarkable.[3] Professor Peckham makes the strong assertion, which my own experience confirms, that a large collection of spiders from the tropics is almost certain to contain as great a proportion of beautifully colored specimens as would be found among an equal number of birds from the same region.[4]

Attoid Jewels.

Some of the Laterigrades also are richly colored. We have several species in the neighborhood of Philadelphia that would attract the admiration of any observer. The yellow and brown markings, varied with red and purple, which characterize the familiar Misumena vatia (Plate III., Fig. 1), may often be observed in the midst of wild flowers of our fields. A small species, apparently of Philodromus, which I am not able to identify, is remarkable for its pleasant grass green hues, with markings of bright red and brown upon the legs and palps. The most brilliant coloring appears to be confined to these four tribes, namely, Orbweavers and Lineweavers among the Sedentaries, and Saltigrades and Laterigrades among the Wanderers. Tubeweavers and Tunnelweavers among the Sedentaries, and Citigrades among the Wanderers, are, for the most part, distinguished by dull and inconspicuous coloring, though it is highly probable that a wider knowledge of the species of these three tribes will uncover many decorated species.

[1] Tropical Nature, page 97.
[2] Malay Archipelago, page 437.
[3] Naturalist on the Amazons, Vol. I., page 106.
[4] Sexual Selection in Spiders, page 10.

Among Orbweavers and Lineweavers there appears to be a preponderance of yellow hues, and the metallic species of these tribes are generally marked by a metallic white or silver. The Saltigrades have a tendency to somewhat darker colors, the reds and browns being more generally prevalent in this tribe; and where metallic colors occur they are usually metallic green, or occasionally blue. Yellows, greens, and dark browns prevail in the Thomisoïds. Uniform browns, grays, blacks, and lead colored or neutral tints are most common among Tubeweavers, Tunnelweavers, and Citigrades.

Metallic Hues.

It will thus be seen that spiders present a sufficient number and variety of facts in coloration to occupy the attention of naturalists. It is to be regretted that these facts have not been so systematized and presented in connection with the habits, industry, and structure of the species as to enable one to consider them with accuracy and satisfaction in their bearings upon many problems that now occupy the thought of scientific observers. Nevertheless, something may be attempted; and even the imperfect contributions of this chapter may, in the future and in other hands, be found helpful.

How shall we account for this variety of coloration? And what underlying causes have influenced the special colors of particular species? In point of fact, color appears to belong to the natural constitution of the spider, being imparted to it at its birth, and preserved through life by the power of heredity. It seems to be an accident or incident of physiological changes which have not been accounted for; and as such it can hardly be considered to have special regard to utility in one direction or another. To quote the language of Mr. Wallace, "Color per se may be considered normal and needs no accounting for. Amid the constant variations of animals and plants it is ever tending to vary, and to appear when it is absent."[1]

Color is Normal.

No doubt it is modified by food, habit, environment, variations of heat, cold, moisture, light, and darkness; but the strong hereditary tendency by which it is controlled is dominant, even amidst the abnormal influences which sometimes more or less modify it. Nevertheless, it may be worth while to attempt to present some of the facts in habit, environment, and structure which seem to be most closely related to the colors and color changes of spiders.

Some of the most remarkable and perplexing facts in aranead coloration are seen in Epeira trifolium, and these have been represented in Plate I., Volume II., wherein several variously hued specimens of this species are given, colored from the individuals themselves, as they were collected from one field in Niantic, Connecticut. The locality is described at length in Volume I., page 292,

Color Varieties of Trifolium.

[1] "Essay on Colours of Animals."

to which the reader is referred. The specimens were all near neighbors, exposed to the same influences of habitat, food, sunlight, etc., and most of them were taken from bushes of the same plant.

They were all domiciled in nests of clustered leaves or of single leaves rolled and sewed together. Let us examine some of these specimens, all of which are females, as we pluck them from their homes, and note their colors. Beneath this nest is a spider whose feet are black and whose legs are white, ringed with black at the feet and around the joints. The body too is white, with only here and there faint black lines bringing out more distinctly the trifolium markings. In the next bush is another, differing from the first only in the fact that the annuli of the legs are brown instead of black. Here is another (Plate I., No. 1), pale yellow on the abdomen, deepening into orange towards the spinnerets underneath the body. The trifoil markings on the abdomen are very faint, indeed, scarcely distinguishable. The legs are a pale, transparent yellow, with red brown rings at the joints. Another specimen (No. 2) resembles No. 1, except that the front of the abdomen is orange below and greenish yellow at the top, the face being light brown. This spider is drawn in the position which it usually assumes when sitting in its nest, or when it rests upon a branch, with the knees bunched up against the abdomen. Still another specimen (No. 3) is dark yellow brown on the dorsum of the abdomen, growing into a deep chocolate at the sides and underneath; the trifoil patterns and spots on the abdomen are chalk white. The legs are orange with brown. The next specimen (No. 4) is drawn as viewed from underneath, the abdomen and sides showing there dark orange, with crimson stripes through the centre and yellow hues along the sides. The legs have deep orange rings on transparent pale yellow.

Still another (No. 5) is colored yellow, the top of the abdomen deepening into yellow brown along the sides and beneath, and has the outlines of the trifolium spots distinctly marked and of a pale yellow. Two short, greenish, longitudinal bars mark the tip of the abdomen. The legs are pale yellow with brown rings.

Strawberry Colors.

In the next specimen (No. 6) the trifoil spots are yellow on a greenish yellow abdomen, the latter deepening to orange on the sides and beneath. The legs have dull brown rings. Yet another specimen is of a bright strawberry tint, the abdominal patterns being a bright yellow, the legs yellow with red brown rings. It is a beautiful object, certainly, as it lies bunched up in the palm of one's hand, and no one looking upon it could deny that spiders are sometimes attractively clothed. Still another specimen (No. 9) has the dorsum of the abdomen orange, which deepens to crimson red below and at the sides, and has light yellow trifoils and spots. The legs are white, with dark brown rings at the joints. A male, Figs. 10 and 11, which we find in the nest of one of the females, is colored yellow, the

The Male.

legs and cephalothorax having brownish rings and bands, and the abdomen being a lighter yellow with brownish spots.

Thus the colors run, with varieties of tints and hues that confound the observer. Most of these spiders appear to be of one age and at the same period of gestation. Those that are least advanced, perhaps, may be said to have the white colors. The next degree of maturity in motherhood shows the yellow tints. The next the deepening brown, and so as the creature ages the colors seem to deepen and brighten. When the last stage of maturity has been reached, and the spider mother has spun her beautiful silken cocoon, depositing therein her eggs neatly and securely blanketed against assaulting enemies and winter frosts, these colors will gradually merge into the dull, dark hues of the sere and yellow leaf of which her nest is built, and so her life will fade away.

The physiological causes of this change in the colors of Trifolium present an interesting study. Other species known to me are subject to changes. In some the change is quite marked. In some there is a great variety of coloring, and particularly of dorsal patterns, as in the case of Epeira patagiata and Epeira parvula, but the Shamrock spider exceeds all species which I have ever observed in the puzzling variety and contrasts, as well as beauty, of the colors it assumes in the closing weeks of its life.

II.

Color Development in Young.

The color of young spiders is almost without exception light yellow or green, whitish or livid, tints that blend well with the prevailing greens of foliage and young twigs, and the grays of bark on trees, of rocks and soil. This is probably due largely to the fact that the tissues are at that time translucent. The effect may also be caused by the absence of acquired food in the alimentary tract and lack of distribution throughout the system of other than the prenatal nutriment.

As young spiders advance in age the color deepens, which is caused, no doubt, by gradual hardening of the tissues, thus making them more opaque. Up to this period no food has been taken, hence the absence of food alone is not sufficient to account for the lighter colors of the first stages after exode. Yellows and browns in various tints occur at this period, and in some cases—though not generally, I believe—color patterns which are characteristic of the various species in adult life begin to appear with more or less distinctness, or at least suggestively. It is not until Sedentary spiderlings have established themselves upon their own webs, and, so to speak, have set up housekeeping for themselves, that the characteristic colors and markings of the species begin to appear with positive degrees of distinctness.

The Attidæ, like birds, moult frequently, and at each moult the markings may change, so that some of the older writers have formed several

species for the different moults of one. These difficulties are increased by the fact that the adult males and females of a species usually differ considerably in appearance.[1]

This is not entirely in accord with the statement of Mr. Cambridge that the pattern of a spider—that is, the design formed by its colors and markings—differs in general but little in immaturity and maturity, excepting that it is usually more distinct in the young and in the female examples: The first of these statements appears to me to be too sweeping, unless the period of youth referred to be placed well on toward maturity. In some species there are striking differences between the colors and markings of the very young spider and those which it attains after one or two changes of skin. Epeira diademata and Zilla x-notata, two of the commonest English spiders, are conspicuous examples of this.[2]

Color and Sex.

According to Peckham, the young spiders often differ from adults, and in many species when the sexes differ when adult, the male being brighter, they are alike until they reach maturity, when the male, along with his sexual development, acquires his brilliant color. Again, soon after hatching, young spiders, probably at the third or fourth moult, begin to show color more decidedly, and the colors are distributed in the patterns characteristic of the species, and as the spiders continue to advance in age and make their successive moults, other and more marked changes may be noted.[3] The truth appears to be that there are differences among species in the degrees of resemblance between immature and adult forms, but that generally the likeness strengthens from the time of hatching onward to maturity.

I give a few observations upon the appearance of spiderlings during and shortly after their cocoon life. These, however, can hardly be fully appreciated by those who do not know the adult species, without consulting the plates in Volume III. But the following species may be compared with figures or descriptions in this volume.

Appearance of Young.

Just after its escape from the egg shell the young of Argiope cophinaria is about two millimetres long. The cephalothorax is a grayish white color, translucent, upon the fore part of which the eyes, which are a brownish color, stand out vividly, seeming to form a large part of the face. The legs are white, translucent, as are also the palps; as the spider sits upon a surface both legs and palps are doubled under the body. In this position the palps seem to be a shorter pair of legs, so that as thus viewed the animal really seems to have ten legs. The abdomen is a yellowish color, except that in the places where the peculiar yellowish irregular marks of the dorsum are seen upon the adult, may be seen irregular markings of pure white.

[1] North American Spiders of the Family Attidæ, page 5.
[2] Spiders of Dorset, xxvi.
[3] Peckhams, "Sexual Selection," pages 14, 15.

Fig. 305 is drawn from a young Cophinaria just out of the shell, and Figs. 306 and 307 from the same a few days older.

Argiope.

When the young Cophinarias have advanced in age a few days the folium upon the dorsum of the abdomen assumes a distinct shield shaped outline resembling that which is common upon the adult forms of Epeira insularis, sclopetaria, etc., the color of the same being a darkish green, and the scalloped margins being surrounded by a white band which extends quite around the fore part of the abdomen. The sides also have a greenish band, the same color prevailing around the spinnerets. The usual aspect of the abdomen is thus green in the centre and lower part of the dorsum, and white along the fore part of the abdomen and the sides. The hairs are quite prominent both on the abdomen and legs. The eyes have a darker hue, and little processes on either side of the base of the abdomen distinctly appear. The abdomen is now in general shape a miniature of the adult form. The legs are covered with greenish bands closely placed. When separated from the mass of its fellow broodlings, a single spider will throw out a thread from which it will hang down, suspending itself by its dragline and weaving a little foot basket, precisely in the manner of the more matured spiders. Three longitudinal bands appear upon the cephalothorax, one in the median line and one on each side. The youngling looks plump, as though well nourished.

FIG. 305. FIG. 306. FIG. 307.

FIG. 305. Young Argiope cophinaria after leaving the shell. FIGS. 306, 307. Appearance after first moult.

Epeira strix.

The young of Epeira strix shortly after its advent from the cocoon (April 14th) often presents a uniform glossy black appearance. After another moult this appearance is somewhat changed, the legs have black annuli around the joints, and the interspaces are of a yellowish brown hue well covered with black spines. The folium upon the abdomen is along its margins jet black, with a median cross like figure of a dark yellowish brown. Bands of the same color surround the scalloped margin along the sides. The cephalothorax has the same general hue of glossy black.

At the time of hatching, the young Gasteracanthas of Africa, according to Dr. Vinson, are round and black, without the pointed spines peculiar to the adult, and with a triangular white spot upon the abdomen. These peculiarities are also characteristic of our California species. Among those sent to me by Mrs. Eigenmann were a number of young in various stages of growth. They are all quite black, and the spines are either lacking or just beginning to push out slight angles upon the otherwise rounded abdomen. (Compare with Plate IV., Volume II., Fig. 8.)

The black color of these young Gasteracanthas is a singular variation from the ordinary color of spiderlings, which is quite light, the colors

being nearly always white, or a faint livid, or a delicate hue of pink or yellow. I do not know whether the absence of spines characterizes the young of those species that show these peculiarities in adult life.

Abdominal Spines.

It may be that the development of these thorn like processes is in some way connected with the development and growth of the young spider, and is only completed at maturity. It would be interesting to know the physiological causes of this vital phenomenon.

Some of those species which have soft conical tubercles upon the fore part of the abdomen show these very early in the young. I have observed them distinctly formed upon at least two of the Angulata group of our American Epeira, gemma and bicentennaria. In the case of Argiope cophinaria the spiderling immediately after escape from the egg (the first moult) appears to be without the processes or bifurcations which mark the base of the abdomen of that species, but after the next moult these show plainly. (Compare Fig. 305 with Figs. 306 and 307.)

When the young of Tegenaria medicinalis first break from the shell, the legs and palps are white and semitransparent. The eyes stand out

Tegenaria.

brown and distinct upon the face. The cephalothorax in the fore part has a slight bluish or lead colored tint, with a touch of yellow at the posterior part near the abdomen. The mandibles are the color of the cephalothorax, but with the fangs prominent, feeble looking, whitish, instead of the dark, horny appearance of the adult. The abdomen is a uniform yellowish hue, at the apex of which the spinnerets appear lead colored, the long, jointed pair quite prominent. The spines are quite manifest on the legs, and hairs are seen on the abdomen. The folium or dorsal figure can be traced, together with the transverse bars, on either side of the median line. In a day or two the color of the legs deepens until they have a leaden hue, upon which the black spines stand out more prominently. The abdomen is a little brighter yellow, and the cephalothorax corresponds in color with the legs. In two days more the yellowish tint has faded from the abdomen, the whole spider has a blackish appearance, caused by the dark hairs upon the lead colored body; the transverse markings stand out more prominently upon the abdomen.

The young of Epeira cucurbitina (English) when extracted from the egg have the cephalothorax and legs of a pale yellowish white color, that of the abdomen being reddish brown. But after their first change of integument they acquire an olive or brownish green tint, the upper part of the abdomen being metallic with whitish spots on each side, with a longitudinal stripe of the same hue parallel with it. On the upper side there is a series of minute black spots.[1] These examples will be ample, when compared with adult forms, to enable the student to note the color changes that occur during the growth of spiders.

---

[1] Spiders of Great Britain and Ireland, page 343.

III.

As spiders further advance in age and make their successive moults, various color changes may be noted. Immediately after moulting the color is always lighter, which is probably due to the fact that the harder skin just cast off prevented the passage of light through the tissues. The new skin is thinner and more translucent. Moulting produces changes in color patterns of a decided kind, at least in certain species.

Moulting Influences.

Phidippus rufus when mature is a dark red spider, the male considerably brighter than his consort. When about one-seventh grown and after the third or fourth moult, the young are dark brown with light yellow legs. Some moults later they are reddish, with narrow, oblique, whitish bars on the sides of the abdomen, and two dark bands on the dorsum, on each of which is a row of white dots. The appearance of the spider changes but little during the next four moults, but after the last, the tenth, both male and female become mature, and acquire the adult color. The appearance of the female after the fifth moult is similar to that of many other females in the genus.[1]

The female of Phidippus johnsonii has the abdomen red and black with a white base and some white dots, while the male abdomen is bright vermilion red, with sometimes a white band at the base. The young of both sexes resemble the mother, until the last moult, when the males assume their bright livery.[2]

In old age the color changes are often quite decided. In some, as Epeira trifolium and Epeira thaddeus, the changes give added brilliancy to the color at certain parts of the body. Some of the color changes of Trifolium are remarkably beautiful, and the same is true of Thaddeus. But advanced age, as a rule, brings darker colors. Orange and brown then have a ruddier hue; yellows darken into orange and brown. Sometimes the yellow patterns are entirely lost, and the spider becomes dark, almost black. There is a grizzled appearance about the animal in this stage which reminds one of vertebrate animals at the corresponding period. These last named changes are manifest in the female spider after the final deposit of eggs.

Colors of Age.

In gravid females changes of color are sometimes noticeable. Some of the bright colors upon Trifolium and Thaddeus are doubtless due to this condition. However, other and perhaps most species during gestation have a lighter color, which may be the result of mechanical changes in structure. The skin becomes distended and more transparent, the pigment is thereby distributed, and thus centres of color are broken up and the coloring matter diffused. Not only the skin, but other

Gestation

[1] Peckhams, Sexual Selection, page 25. [2] Idem, page 17.

parts of the abdomen are distended during gestation, and this distension produces changes in the color of the animal, it may be by modifying in some way the various secretions from the liver and other organs, and in some cases, perhaps, widening the intervals between color centres and color hairs, and breaking up groups of the same.

Effects of Muscular Action.

The little pits or dark spots upon the dorsum of the abdomen, which mark the attachment of the muscles within, seem to me to be centres for the aggregation of coloring material. At least the dorsal patterns appear to be grouped in some regular way around these muscular attachments. Thus the action of the muscles on the skin and chitinous shell or walls seems to compel certain aggregations along the lines of use that form these colors and patterns. It might be important in this connection to consider what is the ordinary effect of muscular action upon the distribution of pigment and colored hairs in vertebrate animals.

The color rings or annuli around the joints of the legs of spiders may be influenced by action of the muscles. The tendency of these darker and more vivid colors is towards the ends of the joints, as though by the attachments and prevailing outward action of the muscles the pigment were forced mechanically or otherwise attracted toward these points. The foot or terminal joint is usually dark, and often black. In the cephalothorax may be noted the same tendency of color to group itself somewhat symmetrically around the points of muscular attachment, particularly the central depression.

IV.

Influence of Sex on Color.

Color and markings are undoubtedly influenced by sex. Peckham, after summarizing the Attidæ of France from the studies of M. Simon, finds that in thirty-nine species the male is plainly unlike the female, being in twenty-six instances much more conspicuous, while in fifty-five the sexes are similar, or, if they differ, the male is no more conspicuous than the female. These facts make it clear that the sexes commonly differ, the male being brighter than the female. Peckham considers it not too much to say that in the Attidæ at least two-fifths of all the species have the male more conspicuous than the female.[1]

Menge, in referring to the greater brilliancy of the male of Micromata ornata, says that it only assumes its bright color as a bridal adornment, and in this connection makes a statement that in the Thomisidæ and Saltigradæ the males are generally more beautifully colored than the females.[2]

Philæus militaris, a common American Attoid, is another illustration. In the male the cephalothorax and abdomen are bright bronze brown, the

[1] Sexual Selection, page 20. [2] Menge, Preussische Spinnen, II., page 396.

former with a wide, pure white band on each upper side and a white spot on the centre of the head, the latter with a wide white band around the base and sides. The female has the brown all covered over with white and gray hairs, which form a more or less distinct pattern of lines and spots.[1]

In Habrocestum splendens, while the young males are not exactly like the adult female, they resemble her much more closely than they do the adult male. This is one of our most beautiful male Saltigrades. The highly iridescent scales which cover the entire body make it impossible to give in a painting a correct idea of its brilliancy, since the color changes in every light. The male only gets his gorgeous livery at the last moult, just as he becomes mature, though in some species the nuptial moult is acquired one moult before maturity.[2]

This prevalent condition of the relative brilliancy of coloring between the sexes of the Attidæ is entirely reversed among Orbweavers. In this tribe there is a strong tendency to inconspicuous colors in males, and frequently in the degree that the females are conspicuous for size and coloring, the males are diminutive and dull.

Color Consciousness.

We have already seen (see Chapter II., page 60), from our examination of the interesting studies of the Peckhams upon the courtship of Saltigrade spiders, that there is a close relation between mating habits and the brilliant colors prevalent among males. In other words, the favors desired from the female are solicited with such a display of the ornamented parts of the male body, as to justify the conclusion that the ornamentation is pleasing to the female, and is presented in the way of soliciting her favors. Of course, if we accept this fact, we also admit that there must be, on the part of both sexes, a consciousness of the presence of color, and the fact that the female at least is so sensitive to the differences in color ornamentation as to be moved towards this wooer or that according to the splendor of his physical finery.

Climatic Influence.

That climate and favorable environment sometimes exert modifying influences upon the general facies and, to some extent, the industry of spiders, is illustrated by Epeira labyrinthea. I have specimens of this species from almost every part of the United States where collections of araneads have been made. It is distributed from the far Northeast to the southwestern portion of California. I have also received specimens in collections forwarded to me by Professor Peckham from several South American States. These southern representatives of the species are larger and decidedly more vigorous looking animals than the northern specimens. The industry of the spider experiences no essential change as far as I can learn. The snare is, perhaps, larger with tropical examples. Specimens of cocoons sent to me from southern California have

[1] Peckham, Sexual Selection, page 17. [2] Id., page 18.

all the characteristics of our northern species, but are decidedly larger. No marked influence appears to have been exerted upon the coloration of the spider itself. But other collections indicate contrary conditions.

Epeira labyrinthea.

The species was collected pretty freely by the naturalists of the U. S. S. "Albatross," in its explorations along the shores of the southern Atlantic and the Pacific, showing an immense distribution over the entire Western Hemisphere. Dr. Marx remarks that specimens collected at the Straits of Magellan are hardly recognizable, for its color has greatly changed. The dorsal folium is nearly obliterated. Only two lighter spots at each side remain, and the whole body is covered with a long, dense pubescence.[1]

If Dr. Marx is correct in his surmise that Epeira cooksonii Butler, which lives in great abundance on the Gallapagos Islands, is related to our Epeira domiciliorum, and that the latter spider has undergone on the Pacific coast so great a change in form and coloration as to be identical with my Epeira vertebrata, this species will afford another example of the influence of climate upon color.[2] I am not satisfied, however, that the last two named species are identical. On the other hand, certain species, as notably Argiope cophinaria and argyraspis, have undergone a transcontinental distribution, covering wide extremes of climate and conditions, without experiencing any notable change in general appearance.

These examples will be sufficient as illustrations of the fact that the influence of climate must vary according to species. The fact is that some of the species probably are more elastic and impressionable in their natural constitution, and thus are more sensitive to radical changes in environment, while others are able to resist such changes more vigorously, and thus retain their characteristics through extreme changes.

Influence of Environment.

Spiders that live upon plants, as a rule have colors that are harmonious with the prevailing greens and yellows, and admixtures thereof, of branches, leaves, and flowers. Spiders that nest in stables, houses, on fences, and like locations, ordinarily have dusky colors, harmonious with the environment; as, for example, Theridium tepidariorum, Agalena nævia, Tegenaria medicinalis. However, I do not find that any great difference in color is observable in the above species when they nest in foliage, as is often the case, at least with Agalena and Theridium. It might be said, perhaps, that there is a slight tendency to darker hues and a more uniform color when the spiders are found in the first named locations.

Ground spiders, as the Lycosids, generally have colors of neutral grays that blend well either with the soil, with rocks, or with stalks of grass and weeds, especially when the latter are somewhat dry. Lycosids found in the neighborhood of streams do not seem to be especially influenced by

[1] Proc. U. S. National Mus., Smithsonian Institn., Vol. XII., page 209. [2] Id., page 210.

the natural color of water; but Dolomedes sexpunctatus, which is so constantly found on the water, sometimes has a tint that at least well harmonizes with that of the stream itself.

Saltigrades follow the rule of the Lycosids; their colors, being chiefly black, gray, and brown, harmonize with the surfaces of rocks, trunks of trees, etc., upon which they habitually seek their prey. Many of them are freely marked with yellow, and thus are also sufficiently harmonized with the color of the leaves. The metallic green and blue on the fangs of some Saltigrades seem almost like a leaf ambush to the body of the creature as it is observed stalking its prey. This suggests the strategy most familiar from its association with the lines of Shakespeare:—

Mimetic Harmonies.

> "Macbeth shall never vanquished be, until
> Great Birnam wood to the Dunsinane hill
> Shall come against him."

It is, perhaps, a not wholly untenable theory that some insects are made less wary by the resemblance to surrounding foliage and the play of iridescent hues from the mandibles of a stalking Phidippus morsitans, for example, as it stealthily moves upon its prey. But independent of the indifference of the ordinary insect to spider presence, the Peckhams have taught us to find the chief service of these gorgeous frontlets in courtship. But what can be their use in the female Morsitans? She is such a ferocious virago that we might suspect in her an example of warning coloration as towards her own lovers.

According to Emerton,[1] in one species of Linyphia from Weyer's Cave, Virginia, the colors and markings of some specimens are as bright as on spiders of the same family living in cellars and shady woods. The other five species are pale in color. On the supposition that all these species drifted from the outside world into the caverns, we must reason from such a fact either, that the species retaining a normal color had been domesticated in the caverns at a much more recent date than the others, or that it was possessed of greater power to resist the changes consequent upon its changed environment.

Color of Cave Spiders.

The influence of cave life upon Anthrobia mammouthia appears to be manifest in this lack of color. Two young Anthrobias were hatched May 3d for Professor Packard, who describes the whole body, including the legs, as snow white, with the legs much shorter than in the adult state. The adult in life is white, tinged with a very faint flesh color, with the abdomen reddish. In some specimens the abdomen has beneath several large transverse dusky bands. Linyphia subterranea as observed living

[1] "Notes on Spiders from Caves in Kentucky, Virginia, and Indiana," American Naturalist, Vol. IX., page 278.

in Wyandotte Cave is pale pinkish, horn brown on the thorax and legs, while the abdomen is dull honey yellow.[1]

Two specimens of Linyphia weyerii in my possession, collected by Dr. Joseph Leidy in Luray Cavern, Virginia, are of a light honey yellow, the abdomen of one individual being darkish brown. As this is a common color for spiders of all conditions, after they have been in alcohol a little while, I am not able to say what may have been the original color of these, particularly as they are not adult.

Bleached by Sunlight.

In the case of Lycosa arenicola, whose habits were studied by me on Coffin's Beach, near Annisquam, Massachusetts, the undue presence of sunlight and heat appears to have produced precisely the same results as the absence of sunlight in Mammoth Cave. The eastern shore of the bay opposite Annisquam consists in part of a stretch of sand hills known as Coffin's Beach. The sand is a bright white color, and is massed at places into elevations of considerable height. The fragrant Bay bush grows in clumps along the edges and summits of these irregular sand hills, and this is intermingled with patches of tough grass, among which are numerous burrows of the Turret spider. These Lycosids are domiciled in the sand, and spread very generally over the dunes. The burrows are dug straight downward, penetrating the upper layer of loose sand, and striking the more compact and moist strata below the surface. The spiders captured were of a light hue, as compared with the same specimens found in meadows, fields, and like environment in the interior. Specimens almost identical with these in color were found by Dr. Joseph Leidy, and subsequently by myself, in the sand at Beach Haven, New Jersey. This pale coloring appears in all other littoral specimens examined. The influence of environment, as manifest in these spiders, was also seen in a grasshopper or locust which is quite abundant on Coffin's Beach, and is almost as white as the sand over which it was found hopping.[2]

FIG. 308. Lycosa arenicola. (A dark specimen.)

Contradictory Effects.

It is certainly confusing to one who studies the influence of light upon aranead coloration to find such contradictory facts as these, viz., that the absence of light results in albinism in the spider fauna of caverns, while the excessive sunlight which beats upon and is reflected by the white sea sand produces the same condition. Evidently something more than the direct influence of sunlight must contribute to these results.

[1] Invertebrate Cave Fauna of Kentucky, Am. Nat., Vol. IX., page 276.

[2] McCook: The Turret Spider on Coffin's Beach, Proc. Acad. Nat. Sci., Phila., 1888, page 333.

But confusing elements do not stop here. Any one who is familiar with our ordinary cellar spider fauna must have observed among them a strong tendency to black or dark colors. The most common cellar spider in the neighborhood of Philadelphia is probably the Tubeweaver Tegenaria medicinalis. It is a quite dark lead color, which is as near black as any of our indigenous spiders. So also Agalena nævia, when it nests in dark places, as it often does, seems to me to add to the somewhat sombre colors which it bears in arboreal and sunny sites, several additional tints of darkness.

It should be noted that in the case of the Turret spider of Coffin's Beach a large portion of the year must be spent in a torpid condition by such individuals as survive the winter, which is severe and long in that vicinity. On the other hand, the white spiders of Mammoth Cave live in a uniform and pleasantly warm temperature. The same, to some extent, is true of the Medicinal spider, which is kept reasonably warm when living in our cellars and other unfrequented places in human habitations, but, unlike the Mammoth Cave Anthrobias, are black. Thus similar conditions of temperature, as well as of light, appear in these cases to issue in opposite conditions of color.

V.

Color Utility: Mating.

I have already considered the theory of Peckham that the bright ornamentation of the male Saltigrade spider serves to attract the attention of the female, and to secure him her favor in preference to duller colored rivals. In the case of Orbweavers, where the conditions are reversed and the female is the more highly ornamented, we may suppose that the point of utility is also reversed, and the brighter colors of the female serve to attract to her the attention of the male. In the case of Orbweavers and Lineweavers, there would seem to be some necessity for this, inasmuch as the females for the most part occupy the centre of their webs, which are often of considerable size, and thus they would require to be marked in such wise that the vagrant male on his courtship excursions could discern his mate at the distance of at least several inches. It seems not an overstrained supposition that both the increased size and excessive coloration of the female would make her a more conspicuous object and thus facilitate the union of the two sexes.

Mimetic Harmony

Again, in a large number of species which are influenced by what we might call mimetic harmony, and to which allusion has already been made, we can readily see how highly useful the general resemblance of environment would be in protecting spiders from various enemies. All the Wanderers, and some of the Sedentary spiders, appear to be subject to those influences which harmonize their color with the surroundings of their daily life. This subject may be more fully considered in the chapter on Mimicry, but it has been necessary to allude

to it in this connection. Here, perhaps, we have a view of the greatest influence exercised by color and, as one may say, the absence of color, upon the life of araneads.

When we come to consider the more highly colored species, particularly in their relation to their habits, the question of utility is complicated by many apparently contradictory facts. Such large and well marked species as those of the genus Argiope, Acrosoma, Gasteracantha, and such brilliant species as the Orchard spider, are found well nigh invariably hanging at the centre of their webs in full view of all enemies and assailants. One who is pursued by the theory of utility can scarcely fail to ask whether these species are protected by their color from any enemies, and, if so, in what manner are they protected? It is certainly natural to suppose that they are more exposed thereby to raiding birds, digger and mud dauber wasps.

Industrial Compensation.

Another question may be mooted, have these species, thus highly colored, and thereby exposed to enemies, any industrial protection which may be considered a compensation? I refer to a few examples bearing upon this inquiry. Argiope cophinaria and Argyraspis sometimes have protective wings of retitelarian lines thrown out on each side of their nets, which guard the dorsal parts of their bodies, and a thick shield like sheeting, which protects the under side. (See Volume I., Figs. 96 and 89.) These spiders are highly colored and conspicuous by size. They dwell in shrubs, bushes, grasses, low trees, and commonly are stationed in the centre of their round webs, having no domicile or tent to which they retire. No doubt, the protective wings are serviceable in warding off attacks of raiding wasps, as well as helping to secure insect food for the occupant. But I find that in a large number of cases these fenders are omitted. The tendency to omit them, if I am not mistaken, strongly increases as the spiders mature in age. Perhaps in this case the size of the animal may be considered as sufficient protection. At all events, I think that the protective wings are rather characteristic of the immature state.

The Insular and Shamrock spiders, which are among the most brightly colored of our fauna, do not hang habitually in the centre of their webs during the day, but live in leafy tents, and their habitat is among bushes, shrubs, and trees. The Insular spider inclines to groves much more strongly than Trifolium. Epeira thaddeus has the same habit. Indeed, it may be asserted generally that many of our most highly colored Epeïroids belong to tentmaking species, a fact which is true not only of the American, but of the European, spider fauna. The facts here seem to point to a special development of industrial protection as a compensation for the exposure of bright colors.

On the other hand, Epeira strix, which is not a bright colored spider by any means, is one of the most secretive Orbweavers in its habits, dwelling

in a domicile of rolled leaves, shrinking away into cavities and holes of bark, in angles of walls, and like positions, occupying at times a well made leafy tent, after the manner of Insularis and Trifolium, and only occupying its snare during the night. It is one of the rarest things to find a Furrow spider, unless it be quite young, suspended upon its orb, trapping flies, in daytime. Notwithstanding its seeming protective color, and the additional protection of its secretive habits, it is mercilessly pursued, in the vicinity of Philadelphia, by the steel blue wasp, which stores numbers in its clay cells.

Seeming Contradictions.

Epeira domiciliorum and cinerea are also spiders of rather inconspicuous colors, the last named particularly so, and both of them screen themselves in tents, though the Domicile spider at least not as habitually as some others.

The Labyrinth spider and Epeira triaranea are among the most strongly protected of our fauna by their industry, having, besides their orbs and thick retitelarian snare, a dome shaped silken tent as a domicile. In addition, Labyrinthea roofs her tent with a dry leaf, or uses it as a shelter for her body. These spiders are strongly marked as to their patterns, and are not inconspicuously colored, but do not have the bright hues which characterize Argiope, Epeira insularis, and some others.

Domicile, Labyrinth, Orchard Spiders.

FIG. 309. Leaf nest of Epeira.

The Orchard spider is one of the most brilliantly colored of our indigenous species, although its hues harmonize well, particularly its green and yellow, with its leafy surroundings. It rests beneath its horizontal orb, where it is abundantly exposed to attack from above, but has straggling, pyramidal retitelarian lines beneath it, which form some protection. It dwells mostly in wooded places, or among shrubs and thick, leafy bushes. Epeira gibberosa is also a brilliantly colored spider. Its industrial protection is more manifest, for it dwells beneath a sort of hammock or structure of lines woven between the edges of a leaf. This hammock protects it above, while the leaf affords good security from beneath (Volume I., page 154), and its green color completes the protection.

Our three indigenous species of Acrosoma, viz., Rugosa, Spinea, and Mitrata, are all, particularly the first two, well marked and brightly colored spiders. They are protected, Mitrata least conspicuously, by spinous processes, if such can be called protections. They live in the centre of their orbs as a rule, and their webs are most frequently found stretched between the trunks of young trees, in openings of groves, woods, and like spots. They seem to me more directly exposed to assault

Spinous Species.

than almost any other of our native Orbweavers, unless, indeed, their preferred site within the shaded walks of groves and woods may be considered a protection.

Gasteracantha, with its strongly developed spines, has much the same habit as Acrosoma, but the spines appear to be wanting in the young of this genus, the very age, one would think, at which they are most needed. However, the young of Gasteracantha, at least with numerous specimens sent from the Pacific coast, are almost black in color, a feature which must certainly be regarded as protective, if bright colors best invite the observation of enemies.

On the whole, the conclusion seems to be justified that many spiders which appear to be more exposed to enemies by reason of bright colors or greater size, possess special variations in industry and habits that in some degree are protective; but there are so many apparent exceptions to this, which require more careful study, that no generalization can now be warranted.

Warning Colors.

If we come finally to consider the bearing of what has been called "warning coloration" upon spiders, there is little to be said. In the case of those numerous species which belong to the Wanderers, the colors cannot be considered as warning, but, as we have seen, are rather protective. As to Sedentary species, I cannot think of any animal that would avoid them as inedible on account of their color, or of any influence that their color could have in warning insects of danger. In point of fact, the colored spiders appear to be as delicate morsels to those that feed upon them as any other sort, and they are just as frequently, and perhaps I may say even more frequently, though by no means exclusively, selected for such purposes.

Insects Unconscious of Danger.

That a warning should be conveyed to insects by the color of a spider at the centre of its web seems to me wholly imaginary, since Sedentary spiders do not capture food directly, but by means of their manufactured trapping instruments. Indeed, I have little faith in the opinion that insects are capable of experiencing anything like a warning, from color or other causes, against the presence of spiders. I feel sure that this is the case with flies, the insects which perhaps more than any other form the staple food of the various aranead tribes. I have often been witness of the absolute indifference of various species of flies to the presence of spiders. One remarkable example is recorded (Vol. I., page 256), in which, during an entire season, I observed numbers of a little black Diptera settling and feeding upon the carcasses of large blue bottle and house flies which had been trapped and trussed within the orbs of Argiope. In several cases these little creatures were observed stationed within the open jaws of their gigantic enemy, sipping juices which the spider was expressing from the fly on which she was feeding.

A fly which had been put into a box with Epeira strix tempted her in vain to make a breakfast upon it. Three times it flew into or against the spider's jaws and escaped. Twice it crept between the front pair of legs; once it lit upon and crept up the hindermost legs; and all the time was walking everywhere around her, utterly unconscious of the presence of an enemy. The spider remained motionless, except when the fly flew into her face, when she made an effort to seize it. At the time she was seated upon the bottom of the box, separate from any snare or web, and thus without ordinary means by which the presence and locality of insects are determined. We may suppose that the spider was confused by the unusual circumstance of separation from her web, and her vision momentarily impaired; but the fly, at least, was in normal condition, hunting food and otherwise acting in a natural way.

In numerous other cases when flies have been placed within boxes where spiders have been confined, I do not remember a single individual that showed the slightest sense of fear, but on the contrary they would run all around, and even settle upon the spider, apparently no more conscious of its presence or of any peril therefrom, than if it had been a clod or chip. The same is true of grasshoppers, hundreds of which have been fed to the large tarantulas that from time to time, during a number of years, I have kept in confinement. Of such insects, at least, it would be highly absurd to argue anything of service in the way of "warning coloration." Bright or dull, large or small, they seem to be absolutely without consciousness of the presence, or fear of the power, of spiders.

General Summary

In taking a summary view of the facts above recorded it may be said, in general terms, that the influences which appear to modify the color of spiders, in various degrees more or less known, are the following: Moulting changes; the effects of advancing age and approaching dissolution; the disturbance of gestation; the distribution of pigment and color hairs by muscular action; the effects of food, environment, and general habit; sexual differences and the excitements of courtship and mating; and, possibly, inimical influences, such as natural enemies and weather changes.

VI.

Consciousness of Color.

How far are spiders conscious of the color elements in their surroundings? They are found among leaves, flowers, and blossoms of all the varied kinds and colors in the vegetable kingdom. Sedentary spiders hang their webs to the branches and leaves of trees, and weave them amidst flowers, often selecting for them sites which strike the observer as choice and notable for beauty. One may find, for example, the pretty web of Linyphia communis hung within an opening upon a morning-glory vine, the bright colored flowers

of which encircled the web like a charming frame to a picture.[1] Again, one may see the round webs of Epeira spun among lilies,[2] and hung within full blossoming sprays of honeysuckle. Indeed, at every point in Nature where flowers appear, there also appear spiders erecting their domiciles, weaving their snares, and spinning their cocoons.

In like manner many of the wandering tribes spend their lives in arboreal situations, continually stalking their prey, and plying the varied industries characteristic of their species among grasses, shrubs, blossoming trees, vines, and beds of flowers. Are they utterly unconscious of the color effects among which they continually move? Or if, on the other hand, they have some sense of color, in what degree is it possessed? These are interesting questions, and to some extent they have been solved, although much remains to be proved.

It cannot, of course, be known that the light waves of various lengths, whose vibrations result in color, produce upon the spider's organ of vision effects similar to those known to man and many of the higher mammals. But that some effect is produced seems clear, and that this is analogous to the color sense in man, we may perhaps safely assume; for we can only think and speak of the sensations of spiders in terms of our own conscious states.

On Crustaceans.

The late Prof. Paul Bert claimed that all animals see the rays of the spectrum as we do; that beyond this they see nothing that is unseen by us, and that, in the extent of the visible region, the differences between the illuminating powers of the different color rays are the same for them as for us.[3] He rests these conclusions on experiments made on a small fresh water crustacean belonging to the genus Daphnia. Sir John Lubbock dissents from this generalization as too sweeping and based upon an insufficient foundation,[4] but, as the result of numerous experiments with Daphnia pulex, concludes that while it would be impossible to prove that these crustaceans actually perceive colors, to suggest that the rays of various wave lengths produce on their eyes a different impression other than that of color, is to propose an entirely novel hypothesis. At any rate, he thinks that he has shown that they do distinguish between waves of different lengths, and prefer those which to our eyes appear green and yellow.[5]

On the other hand, M. Merejkowski denies to the crustaceans any sense of color whatever. He thinks that they distinguish very well the intensity of the ethereal vibrations, their amplitude, but not their number. In the mode of their perception of light there is a great difference

[1] Vol. I., page 344, Fig. 335.
[2] Ibid., Fig. 104.
[3] "Archive de Phisiologie," 1869, page 547.
[4] "Ants, Wasps, and Bees," page 220.
[5] Sir John Lubbock: "On the Sense of Color among some of the Lower Animals," Linnæan Society's Journal Zoology, Vol. XVII. (1883), page 214. See also "Senses and Instincts," page 228.

between the lower crustaceans and men, as well as between those animals and ants. While we see the different colors and their different intensities, the inferior crustaceans neither behold any color or the different variations of intensity therein. We perceive colors as colors, they perceive them only as light.[1]

Mr. Alfred R. Wallace does not admit that the fact that the lower animals distinguish what are to us diversities of color, proves that their sensations of color bear any resemblance to ours. The insects' capacity to distinguish red from blue may be and probably is due to preceptions of a totally distinct nature.[2]

Color Sense of Insects.

We have much testimony that insects have a decided color sense. Most important and decisive are, perhaps, the remarkable investigations of Sir John Lubbock, whose experiments indicate that ants are sensitive to the ordinary colors of the solar spectrum. It becomes probable, moreover, that the ultra violet rays must make themselves apparent to ants as a distinct and separate color, of which we can form no idea, but as unlike the rest as red is from yellow or green from violet. He adds, that as few of the colors in Nature are pure, but almost all arise from the combination of rays of different wave lengths, and as in such cases a visible resultant would be composed not only of the rays which we see, but of these and the ultra violet, it would appear that the colors of objects and the general aspect of Nature must present to ants a very different appearance from what it does to us.[3]

Lubbock has also shown that bees have a decided preference between colors, and that blue is distinctly their favorite, although yellow is much liked.[4] He also demonstrates that wasps are capable of distinguishing color, although they do not seem to be so much guided by it as bees are.[5] The fact having thus been established, that among two classes of the Arthropods, namely, the Crustacea and the Insecta, there are found genera which show a decided color sense, prepares us to expect the same fact in the case of the Arachnida, and indeed of all other Arthropods.

Spiders: Peckhams' Experiments.

The best sustained and most conclusive experiments upon spiders themselves, of which I have knowledge, were made by Professor and Mrs. Peckham in the neighborhood of Milwaukee, Wisconsin.[6] Their method of procedure was as follows: A cage was constructed, formed of four differently colored compartments, all made of glass and opening freely into one another. The cage was placed on a table on a covered porch, with the wall of the house on one side, while the other sides were exposed to light. A

[1] "Les Crustacés inférieurs distinguent-ils les couleurs?" (Do the inferior crustaceans distinguish color?) Par M. Merejkowski. [2] Wallace, "Tropical Nature," page 238.

[3] "Ants, Bees, and Wasps," page 220. [4] Ibid., page 310. [5] Ibid., 316.

[6] "Some Observations on the Mental Powers of Spiders," Journal of Morphology, Vol. I., December, 1887.

spider was then admitted to the cage and, after having become sufficiently domesticated, was gently driven into a specially colored compartment, say the blue. It was then left without interference to select such position as it might prefer in any one of the four differently colored compartments. When the spider had changed its position and remained therein a sufficient time to indicate a preference for the color under which it rested, it was again disturbed and moved to another color. If, for example, it settled within the red compartment, it was transferred to the yellow, and so on, a record being made of the various changes and preferences. This process was continued during several days, in which several hundred experiments were made. As a result it was found that among all the spiders experimented with 181 preferred the red, 32 the yellow, 11 blue, and 13 green. The preference of the spiders for red was thus decidedly marked, resembling, although in a more marked degree, the preference of ants for the same color, as demonstrated by Sir John Lubbock's experiments,[1] which appear to have suggested those of Professor Peckham.

Spiders Prefer Red.

A test case was made which gave a striking result, quite in confirmation of the experiments as above described. An individual of Lycosa nigroventris, which had shown a strong preference for red, choosing that compartment 33 times out of 41, was temporarily blinded by covering its eyes with paraffine. When put within the cage it was found that the spider remained quiet in whatever compartment it was placed until it was driven out. If placed in the blue compartment, with its eyes as close as possible to the red, it showed no inclination to enter, although this color had before proved so strongly attractive. Its preferences, or rather its locations, during the resulting experiments, are recorded as follows:—

Preferences after blinding: Red 6, yellow 6, blue 6, green 5.

Preferences before blinding: Red 33, yellow 5, blue 0, green 3.

Such results leave scarcely any room for doubt that in some way the spider had been influenced by a color sense, since, while it possessed normal vision it expressed a most decided preference for the red color, but when temporarily deprived of vision settled indifferently and about equally in all the colors represented in the series, there being no stronger preference for red than there had been in previous experiments for the blue compartment, which it had entirely shunned. These results seem to justify the conclusion that there exists a color sense in certain spiders.

It is to be remarked, however, that in all the cases recorded, and apparently in all experimented upon, the individuals were chosen from the Lycosids alone. These spiders undoubtedly have a keen sense of sight, although I am inclined to think that in this respect they are inferior to

[1] "Ants, Bees, and Wasps," page 189.

some other groups. Their habit keeps them during much of their life concealed within earth burrows, or little caves excavated and fitted up by them under stones, logs, and like surroundings. They move over the ground or water, where they stalk their prey, and are not as apt to be found in arboreal situations among flowers, blossoms, and leaves, as other tribes of the Wanderers, the Saltigrades and Laterigrades.

Misumena vatia.

There is one well known species of Laterigrade spider, Misumena vatia, whose habits have awakened in my mind the query whether it might not be influenced by a decided color sense in the selection of certain sites. Most araneologists have observed this species stationed upon yellow flowers, as the golden rod and the brown daisy which is popularly known in our section as "black eyed Susan." Misumena lurks upon this flower with its legs spread out within the very centre, and so closely corresponding in color to its floral site that one must look closely ere he discovers it. The yellow centre of the common ox eyed daisy is also a lurking place for this spider. I have found the same species nestled within the petals of a half opened tea rose, and then its color also corresponded with its environment, being white, with various delicate shades of green and pink. (Plate III., Fig. 2.) In these cases we are forced at least to face the question, was the spider moved in such selection by the color of the flower? If we say yes, then we are also constrained to the conclusion that, in some way, the aranead must have been conscious of the fact that its peculiar color harmonized with the color of the flower which it sought as a stalking point for the capture of its prey.

It is doubtless true for the most part that light is perceived by spiders, and arthropods generally, by the eyes, and not chiefly by the skin. Sir John Lubbock has shown, by a series of ingenious experiments, that ants perceive the ultra violet rays with their eyes, and not, as suggested by Graber, by the skin generally. These experiments have been repeated and the conclusions verified by an observer so careful and experienced as Dr. Auguste Forel.[1] Nevertheless, it seems to me probable that there is some, and it may be considerable, perception of light by the skin of spiders.

The abdomen of spiders is included within a soft integument which is frequently covered heavily with hairs. May it not be that this soft skin is far more sensitive than the hard chitinous enclosure of the abdomen of insects? May it not, therefore, be that such a spider as Misumena vatia is led to settle within those flowers which correspond in color to itself, by that comfortable feeling which results from the harmony of an individual with its environment, and which may be caused, for all we know, by the fact that the yellow rays of the flower are perceived by and agreeable to the sensitive skin of the spider? In thinking of the power of spiders to distinguish the various hues, may we not be justified in calling into play

[1] Lubbock on the Senses of Animals, page 211.

this sensitiveness of the entire skin, instead of limiting the perception to the eyes alone?

There is indeed another theory which may be suggested, namely, that the color surroundings of the spider, in some manner not now explicable, so rapidly influence the organism of the creature that a change of color is produced in harmony with its environment. Can we suppose, in this case, that the spider possesses the power to influence at will the chromatophores or pigment bodies, so that they may change her color with changing site?

Seeking Insect Resorts.

There is another explanation of the above peculiar habit of Misumena. Many insects are strongly attracted by yellow colors, and as insects are the chief food of spiders, it is natural that the familiar resorts of insects should be the places most affected by spiders. That insects have such attraction to colors has already been shown, and that they are drawn to yellow colored flowers has been fully established by Müller in his remarkable volume on Alpine flowers.[1] This author gives a table recording the numerous visits of various insects to flowers of different hues; and a study of the table shows that butterflies, bees, flies, and gnats, and other insects manifest a strong preference for yellowish white and for yellow flowers. With such a fact as this in view, we may, perhaps, conclude that the habit of Thomisus and Misumena to frequent flowers of the character above described, resolves itself into the well known instinct of all animals to seek their food in those resorts where the supply is most abundant and accessible. This explanation does not, of course, exclude the fact that the spider, in seeking such favorable site, may be guided by its sense of color, but it reduces it to a subordinate rank.

VII.

Relation of Color to Cocoons.

Walckenaer[2] advanced the idea that the form of the cocoon corresponds with that of the abdomen of the mother. This is in some measure correct, for the abdomens of spiders have most frequently an oval shape, and this is substantially the shape of the cocoon. But when one comes to compare the shapes of the abdomens of individual spiders with the shapes of their cocoons, the exceptions are so numerous and decided that no such generalization can be accepted.

The same author suggested that some correspondence exists between the color of the cocoon and that of the mother's abdomen. The facts, however, at least as far as American spiders are concerned, will not sustain this theory, except in a general way. For example, the colors of the abdomen of Argiope cophinaria are yellow, black, white, and brown.

[1] Müller, Alpen Blumen, page 487. [2] Aptères, Vol. I., page 147.

The colors of her cocoon are yellow, white, and brown. Argiope argyraspis has yellow, black, and silvery white upon her abdomen. Her cocoon is yellow and white. Argiope argenteola has an abdomen whose colors are metallic white or silver, yellow, and black. Her cocoon is green or yellow, or a combination of green and yellow on the outside with a white tuft within. The Insular spider has for its abdominal colors yellow, orange, and brown. Her cocoon is a uniform yellow. The Bifid spider has for its prevailing colors a light greenish hue intermingled with a livid yellow and a little brown. Her cocoon is a dull green color.

The prevailing colors of Orbweavers' cocoons may be said to be yellow and white. Sometimes the yellow shades into green, sometimes into brown.

Prevailing Spider Colors.

The dark or blackish cocoons, when examined carefully, are found to owe their shade to the compactness of the threads of which they are spun and the presence of gum. The above colors, namely, yellow and white, are the prevailing ones among Orbweavers themselves. The yellows sometimes shade into green, oftener into brown, livid, and orange. The white frequently becomes metallic, having a silver sheen. There is, therefore, some basis for suggesting a correspondence between the color of a cocoon and that of the spider, or abdomen of the spider, which spins it. The harmony is more apparent, as far as my observation extends, among Orbweavers than other araneads; but there are not enough facts in hand to justify a generalization.

Turning from the Orbweavers to other tribal groups, we find that the exceptions are so many and striking that they appear at once to wholly disparage the theory. Most Citigrades and Tunnelweavers, and many Tubeweavers, are dark colored, but their cocoons are quite uniformly white. For example, the well known American tarantula, whose large cocoon is a white ovoid ball three inches long, has a dark reddish brown and black coat.

Cocoon Colors.

Tegenaria medicinalis is a quite dark, almost black spider, but she spins a white cocoon. The same is true of Tegenaria persica, whose clustered cocoons are white when originally spun, although the mother covers them with dirt, and thus soils the appearance. The Speckled Tubeweaver is a dull creature, yet she spins a beautiful white cocoon, although she also mars its whiteness by adding extraneous material. With many of the Drassids the same rule obtains. Without multiplying examples, this may be said fairly to represent the color relations of American araneads to their cocoonery.

An examination of the colors of European cocoons, as given by Walckenaer, Blackwall, or Simon, or by Staveley,[1] in her tabular arrangement of cocoons and eggs, will show that the same fact obtains among the spiders of Great Britain and Ireland. We learn from this table that a great

[1] British Spiders, pages 269–275.

majority of British cocoons are white; green or greenish, yellow, and yellow brown being the other colors represented. These colors are distributed quite indifferently of the maternal colors.

The color of the silk extruded from the spinnerets of spiders of all tribes in the construction of snares is, with few exceptions, white, sometimes having a steel blue tint, and often a lustre which gives it the appearance of spun glass. There are some exceptions to this rule, as, for example, the round web of Nephila is uniformly woven with yellow silk; and perhaps a wider study of the spinningwork of araneads will show that there are other exceptions, and perhaps many of them.

Color of Silk.

The differences of color in the spinning silk of araneads appear in the construction of the cocoon. Many cocoons are composed of white silk, perhaps it may be said the majority of them, but others again show some pretty varieties of color, and in some species several hues of silk will be used in weaving one cocoon.[1]

Among Orbweavers the colors used in cocooning are principally white; but one frequently finds yellow in various shades, green, and sometimes brown. A few Lineweavers make colored cocoons, and among Tubeweavers may be found a few species whose cocoons are various shades of red, sometimes quite bright. I often find these cocoons in the shape of little plates, with the convexity upward, attached to bark and stones, and showing a very dainty appearance, but have not been able to fully identify them with the species making them.

An examination of the spinning glands of spiders under the microscope will show, in some species at least, as Argiope cophinaria, several colors represented in the liquid contents. The causes controlling the secretion of these specially colored silks are, of course, physiological, but one cannot presume to guess even what they may be.

VIII.

The forms in which the coloring materials are arranged constitute the various patterns or marks that characterize spider species. These patterns are most varied and prominent upon the dorsum of the abdomen, although the venter and the sternum are also sometimes highly colored. While there is much variety in the arrangement of these patterns, there is, on the whole, a general tendency to form a folium or leaf shaped outline, scalloped on the outer margin. This folium outline appears to have some orderly relation to the little pits or points of muscular attachment, and, in a general way, may be said to be regulated by those sections of the abdomen which have commonly been held to

Color Patterns.

[1] See Chapter IV., page 80, and Plate IV., Figs. 3, 4, 5.

indicate a segmentation. In other words, some writers are disposed to consider the abdomen as segmented, and, in a rough way, the symmetrical divisions in the pattern folium may be said to outline the articulations of the segments.

Cephalothorax and Legs.

The cephalothorax is most frequently uniform in its color, commonly with longitudinal stripes of different shade. It follows, in a general way, the coloration of the legs, which it resembles in its chitinous character, the entire fore part of the body having the hardness which is characteristic of the enclosing walls of insects. The abdomen, on the contrary, is enclosed in a soft skin, a fact which exposes it to injury, and causes its rapid decay after death, one of the principal difficulties in the way of preserving specimens of spiders. On the cephalothorax there are often several longitudinal bands, one on each side, near and indeed quite surrounding the margin, and two drawn from the suture of the caput backward. There is also frequently a band of color in the median line from the middle of the eye space backward. The legs are usually colored like the cephalothorax, and are generally uniform in hue, except that at the joints there are rings of color usually darker than the rest of the leg. The feet are nearly always black or blackish.

Causes of Color.

In order to determine if possible the structural causes producing color in spiders, I made studies from a number of dissections of various species chosen with special regard to variety and brilliancy of colors. Among these are Argyroepeira hortorum, Argiope argyraspis, Argiope cophinaria, Argiope argenteola, Epeira insularis, Gasteracantha cancer, and Phidippus morsitans.[1] I do not speak of the results positively, for the studies are in a field where trained histologists alone are competent to decide. But I venture to give some indications of what appeared to me, in the hope that others may follow the path suggested, and reach positive determinations.

Metallic Hues.

The metallic white upon the cephalothorax of Argiope argyraspis is produced chiefly by a vast number of white hairs. These are packed closely one upon another and reflect white light, the combined reflections forming the metallic appearance of the object. The metallic hues of the abdomen of Argyraspis are produced in part by closely thatched white hairs that reflect white light in the manner of those upon the cephalothorax. The black transverse bands on the abdomen are produced by amorphous granules of black pigment just beneath the skin, which thin out towards the margin of the band, becoming yellow as they diminish. There appears also to be a diffused yellow stain in the chitine, and, in addition, white pigment bodies which resemble the chromatophores that give the color in frogs and lizards, for example.

[1] I had purposed to include in this volume a plate of colored drawings representing, in a general way, the indications of these studies, but sundry disappointments and delays have compelled the postponement of this plate to the third volume.

Argiope.

In Argiope cophinaria the metallic color of the cephalothorax is produced by hairs in the same way as with Argyraspis. These hairs are wavy; there appear to be two kinds, one flattened, with a wavy outline, having somewhat the appearance of cotton fibre, which may, however, be produced by irregular cavities or spaces within the hairs. Others again, present a similar appearance, but are cylindrical. On the abdomen of Cophinaria the colors are produced chiefly by pigment granules beneath the epiderm, the chitinous layers of which are arranged in beautiful undulating lines.

The pretty orange color upon the thigh of Epeira insularis is produced chiefly by vast numbers of pigment granules lying beneath the epiderm, the secreted layers of which are arranged in diamond shaped figures.

The Orchard Spider.

Argyroepeira hortorum, the most beautifully colored of our indigenous spiders, makes a fine object for mounting in order to show colors. The hairs have little or nothing to do in producing these varied hues, which are due to green and yellow pigment granules, and to what appear to be chromatophores. These chromatophores are white for the most part, though some of them are yellow tinted, and they yield a strong white reflection, which, it seems to me, is a chief agent in producing the brilliant silvery white of this aranead.

In the case of Phidippus morsitans the color of the abdomen is due to several causes. The black shades with dark green metallic reflection on the sides are produced chiefly by dark green pigment granules underneath the skin, and in part by black hairs. The white spots on the sides of the dorsum are composed of peculiar white lanceolate hairs laid one upon another. They are marked by longitudinal striations on the surface, which give it, under the lens, the appearance of a minute ear of Indian corn. The little yellow lunettes of color on the dorsum near the apex appear to be composed of somewhat similar hairs, of nearly the same shape, but a little more elongated, yellow in color, and these, instead of longitudinal grooves, have slight feather like projections or papillæ irregularly distributed over the surface.[1]

The remarkable metallic green on the mandibles of this species is produced by a method quite different from any of those above named. The surface of the mandibles is broken up into a number of rugosities, arranged, though somewhat irregularly, in arcs of circles. These ridges appear to act as prisms, refracting the light; and to this evidently is due the brilliant metallic color which has attracted the attention of all observers of the species. Under a microscope the minute lunettes and waves of green light are readily distinguished; but the natural eye does not separate

[1] These hairs in the color patches on the abdomen of P. morsitans appear to be of the type of Mr. Wagner's clubshaped hairs. (Fig. 297.)

the several groups of refracted rays, and perceives them as an unbroken band of metallic green color.

These cursory examinations appear to suggest that the structural causes of color in spiders are probably the following: First, color stains diffused throughout the tissues; second, pigment granules of various hues distributed beneath the skin; third, pigment bodies or chromatophores; fourth, the reflection of light from the surfaces of thickly overlaid or thatched hairs; fifth, by hairs of various colors and peculiar forms, in some degree analogous to the scales of the Lepidoptera; sixth, certain colors, particularly the brilliant metallic colors, are produced by refraction of light from broken or ridged surfaces of the epiderm, that appear to act as prisms.

Summary: Color Causes.

Little attention has been paid to the structural causes of color in spiders, and scarcely more to the form of the color hairs, and the manner in which they are grouped and overlaid in order to form the various color spots and pattern outlines produced exclusively or in part by them. The subject might well repay the careful study of the microscopist, and it may often be found that these color hairs will show many varying forms, corresponding with genera or even species.

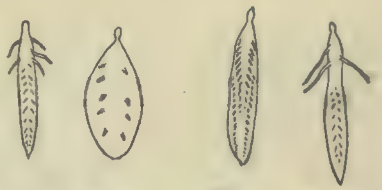


FIG. 310. FIG. 311. FIG. 312. FIG. 313.
Micaria longipes.
FIGS. 310 and 313. White scales from spots on abdomen. FIG. 311. Scale from hinder half of abdomen. FIG. 312. Scale from front of abdomen. (After Emerton.)

Mr. Emerton says[1] that the hairs or "scales" usually found on the Drassidæ and Agalenidæ are feathered.[2] Each scale, as far as he had noticed, is uniformly colored. Along the edges of the red spot in Geotrecha crocata, for example, red and black scales are mixed, but each scale is either all red or all black. The scales of Micaria longipes[3] are either white or brown. The iridescence of the abdomen, which is very marked in certain lights, he had seen on the individual scales. In general form these hairs resemble those which I have seen on Phidippus morsitans.

Color Scales.

[1] In a letter to the author. [2] See New Eng. Drassidæ, plate iii., Fig. 3, e.
[3] Id., plate iii., Fig. 1.

PART V.—HOSTILE AGENTS: THEIR INFLUENCE.

CHAPTER XII.

MIMICRY IN SPIDERS.

The subject of mimicry among spiders, as with other animals, is most interesting and yet most difficult to treat. I accept the word as one generally used among naturalists, to express certain resemblances, more or less complete, between a spider and surrounding objects in Nature. I do not include within the word the idea that the volition of the spider controls these resemblances, except in a very limited degree, which will hereafter be pointed out. The theories of the origin of mimicry, which have been discussed by many naturalists, appear to me to rank little higher than more or less ingenious suggestions unsupported by facts sufficient to justify them as scientific inferences. But at present this condition of things seems unavoidable, and by patient and careful accumulation of facts chaos may at last yield to order and well defined law.

Among spiders the various kinds of mimicry may be divided into the following: First, industrial mimicry of plants and other objects or environment; second, form mimicry of animals; third, form mimicry of environment; fourth, color mimicry; fifth, cocoon mimicry; and sixth, death mimicry. The last of these will be considered in another connection.

I.

Industrial Mimicry of Environment.

The most remarkable examples of industrial mimicry of surrounding objects are to be found among the Trapdoor spiders, as recorded in the charming pages of Moggridge, some of whose figures I have thought well to reproduce in Plate II. of this volume. These animals, which make burrows in the earth, whose openings are closed by doors swung upon a hinge of thickened silk, are in the habit of covering the outside of their doors with dry leaves or living moss, so that they resemble the surrounding site, in which they are placed so closely that even Mr. Moggridge, when looking for them, was often deceived.

Perhaps in no case is the concealment more complete than when dead leaves are employed to cover the door. In some instances a single withered olive leaf is placed in to cover the trap. In others several leaves are woven together with bits of wood and roots, as seen at Plate II., Figs. 1 and 2,

which represent the projecting entrance of a nest of Nemesia meredionalis at Mentone. Fig. 1 shows the door closed and well disguised by resemblance to the dry olive leaves which cover the ground in the vicinity of the nest. Fig. 2 shows the same tube with the door thrown open. The effectiveness of this disguise is at once apparent. It may be questioned, however, whether it is made with deliberate intent at mimicry. The spider's purpose in attaching leaves to the outer surface of its door is doubtless protective. But may it not be that, moved by ordinary self protective instinct, it simply took the first available material, without regard to mimetic resemblance?

Cutting Ants.

I may illustrate this by referring to my studies of the parasol or cutting ant of Texas.[1] My first experience of a formicary of these insects was discouraging. I had encamped in its vicinity on the strength of information that it was a large and active hill; but at a morning visit it seemed utterly abandoned, not a sign of life or activity anywhere present. The mound was dotted over with forest chippage, bits of twigs, dried leaves from an overhanging live oak, but no entrance into the nest appeared. Returning to the place in the evening I found that vigorous life had succeeded the semblance of death. Numerous openings appeared all over the surface of the mound, out of which myriads of insects were pouring, streaming away into the surrounding country, engaged especially in harvesting leaves from the immense live oak tree that overhung. The change was readily explained by subsequent studies. I found that the ants are in the habit of closing up their doors after their night's work, and when the upper part of the tubes which lead into the main formicary have been filled to the distance of about an inch with various chippage and sand, piles of dry leaves and twigs are erected above the opening. These chips form a part of the permanent property of the ants, for I observed that the same pieces were used day after day. The mimicry in this case was complete. The surface of the mound was made to resemble a bit of natural soil covered over with piles of dried leaves and twigs. It effectually deceived me, although I was on the lookout for the insects. Yet I have never thought that the ants designed to produce such a mimetic harmony. They simply gathered such dry leaves and other materials as were convenient, and the fact that these so closely resembled the surface of the mound was accidental. May it not be that some of the striking resemblances in the doors of Trapdoor spiders are produced in the same way?

Striking illustrations of this mimetic resemblance are shown in Figs. 3, 4, and 5 of Plate II. Fig. 3 represents a moss covered sod, pierced by the tube of the nest of Nemesia cœmentaria, the door of which is entirely concealed from view, and only discovered by one who happened to cut

[1] Proceedings Acad. Nat. Sci., Phila., 1879, page 33, sq.

through it in digging up a plant. The moss on the trap grew as vigorously, and had in every way the same appearance, as that rooted in the surrounding earth, and so perfect was the deception that Mr. Moggridge found it impossible to detect the position of the closed door, even when holding it in his hand. No doubt many nests escape observation in this way, and the artifice is more surprising because there is strong reason to believe that this door garden is deliberately planted with moss by the spider, and not the effect of mere chance growth.[1] Figs. 4 and 5 represent a section of earth covered with a delicate moss, which includes the trapdoor of Nemesia cœmentaria. The door is shown open at Fig. 4 and closed at Fig. 5, and the concealment of the door, although not so striking as in Fig. 3, is nevertheless quite manifest.

Mimetic Trap-doors.

In the case of Trapdoor spiders which make a thin or "wafer door," as Moggridge calls it, there is but a thin coating of earth on their upper surface, since it is rare to find any of the larger mosses or lichens growing upon them. But, as if to compensate for this deficiency, a variety of foreign materials is employed, which are scarcely ever found in the thick cork doors, such as dead leaves, bits of roots, straw, of grasses, etc., and Moggridge had seen freshly cut green leaves, apparently gathered for the purpose, spun into a door which had recently been constructed.[2]

There is the widest possible difference between nest and nest in the degree of perfection in concealment; and although, as a rule, the surface of the upper door harmonizes well with the general appearance of its surroundings, there are some individual nests in which it readily catches the eye and even attracts attention. Mr. Moggridge saw nests in mossy banks where the door, being made of nothing but earth and silk, showed distinctly as brown patches against the green. These doors even when surrounded by earth were often easily detected, because when they dried up, as they quickly did, they became much paler in color than the earth of the bank which retained its moisture.[3]

Self Protection.

Thus it seems that the simple instinct to cover in the door, and so protect the artificer from exposure to weather and enemies, was the dominant motive. Material was chosen from the immediate vicinage suitable and convenient for closure, and no purpose appears in the act to select such material as would disguise the nest. In other words, a sense of security by means of sheltering barriers dominated the spider's mind, and security by means of mimetic harmony or protective resemblance appears to have had no place at all.

Some support for this opinion appears to me to be derived from Mr. Moggridge's statements as to the mode in which some of these Trapdoor spiders work. He fastened back the doors of several tunnels, in order to test the mode in which the inmate would deal with this difficulty. In one

[1] Trapdoor Spiders, page 97. [2] Ibid., page 103. [3] Ibid., page 103.

case he observed that a new covering had been cleverly extemporized out of three fallen olive leaves, taken from the vicinity, which were loosely spun together and attached by one or two threads to the margin of the tube. This formed an admirable concealment, but did not move freely as a door, the web being too imperfect. Two days later, however, it was completed, and had become a perfect door, moving on a hinge just within and below that of the former door, which still remained as it had been fastened. The other nests remained in the same condition as before, only that a little moss had been dragged into the mouth of one tube, which had been partially closed with its own lip.[1]

Nearby Objects Taken.

Moggridge further states that Trapdoor spiders, Nemesia meridionalis, will make use of various objects strewed near their nests, in order to build up a new door. This he tested by placing bits of scarlet braid along with particles of moss and fragments of leaves, in a circle around the opening of the tube, and about two inches away from it. Nevertheless, it is apparent that these Trapdoor spiders do exercise some discrimination in the choice of materials, for Mr. Moggridge observed several instances in which, when the door of the cork nest had been removed, if the door had been originally covered with moss, it would again be used in its reconstruction, even though the mouth of the tube were then surrounded by bare earth.

Thus, in reasoning upon the power of the spider to disguise the entrance to its habitation by mimicking surrounding natural objects, we are brought in contact with this apparent defect of rational action. This point Moggridge further illustrates by a case in which he had cut out a little clod of mossy earth about two inches thick and three inches square on the surface, containing the top of the tube and the moss covered cork door of Nemesia cœmentaria. He found, on revisiting the tube six days later, that a new door had been made, and that the spider had mounted up to fetch moss from the undisturbed bank above, planting it in the earth which formed the crown of the door. Here the moss actually called the attention of an observer to the trap, which lay in the little plain of brown earth made by the digging. He subsequently saw many examples of the same sort, and purposely removed several cork doors from mossy banks, in order to observe this point.[2]

Hunters' Secretiveness.

If in the above cases the spiders appear to have been guided by the simple wish to protect themselves with the first available material, in other cases the mimicry seems to be due to the natural secretiveness of animals seeking prey. Mr. Moggridge detected the remains of insects, and especially ants, in the nests which he examined in situ. Frequently, however, one may open several in succession without finding any of this débris, and at other times it will

[1] Trapdoor Spiders, page 121. [2] Ibid., page 120.

only be detected beneath the bottom of the tube, layers of silk having been spun over successive layers of refuse. The horny crops of ants form by far the largest proportion of these remains, and Moggridge was struck by the number of instances in which, while digging out ants' nests at Mentone, he found Trapdoor burrows, especially those of Nemesia manderstjernæ and Nemesia moggridgii in their midst, the tubes often traversing the very heart of the ants' colony, and coming into close contact with their galleries and chambers.

In these instances the trapdoors had almost always escaped his notice, and, indeed, they so closely resembled the surface of the ground that even when he knew, from having accidentally cut across the tube below the ground, that one of these doors must lie near a given spot, yet he could only discover it by following the passage below upwards. This perfect concealment the discoverer thought of essential importance to the spider's success in life, for if they once alarmed the whole colony of ants and let them know the exact whereabouts of their lurking place, they would soon learn to avoid it.[1]


Fig. 314. The tree Trapdoor spider's nest. Pseudidiops opifex. (After Simon.)

The fact of mimetic resemblance in the tubular snare of the Purseweb spider has already been alluded to. I have seen hundreds of these in various parts of Florida, and have before me several score specimens. These are covered on the outside with particles of sand, and even more freely with the brown wood mold which has accumulated in large quantities around the trunks of trees in Floridian forests where the spider abounds. The resemblance of the tube to the bark of the tree against which it is planted is close, much closer, in most cases, than is represented in the drawing Plate II., Fig. 7. As the spider is dependent for her supply of food upon the number of insects that crawl upon her tube, we may suppose that she derives considerable advantage from this resemblance, inasmuch as it allows her to creep upward to where her victim rests, or encourages the victim to crawl towards the point where she lies in wait to fling her web around it.

Purseweb Spider.

An example of nest architecture among Trapdoor spiders which may be classed in the same category as the above, is a species which Mr. Eugene Simon describes as Pseudidiops opifex. (See Fig. 314.) This aranead

[1] Trapdoor Spiders, Supplement, page 237.

constructs a tube with a trapdoor opening, in every respect resembling that of species which burrow in the ground, except that the tube is placed upon the bark of various trees and ordinarily lodged within the furrows of the same. Mr. Simon[1] found specimens of these upon trees of Venezuela, South America, and I have seen a number of examples in the collection of the British Museum at Kensington, London. These were of various sizes, some of them with doors no larger than a pin head, yet perfectly constructed and exact miniatures of that made by the adult. The utility of this mimicry is apparent. The insects which alight and walk on trees, must often go over and around this trap, which in appearance and texture so closely resembles its site. Thus opportunity and facility are afforded the spider, waiting at its partly open door, to seize its prey.

Tree Trap-doors.

II.

Among spiders, the form of other animals is sometimes mimicked. The most striking example is that of the little group of araneads which, by stricture of the abdomen and shape of the head, are made to resemble the form of certain ants. Simonella americana Peckham is an example of this form mimicry. (Fig. 315.) One specimen of this spider is recorded as having been found running among leaf cutting ants.[2] Certainly there is a sufficient resemblance between the two creatures to permit one to think that a spider so formed might run upon the ground among a marching or working column of these emmets without any great fear of detection, provided the ants had no better means of discovering the presence of friend or foe than their eyesight. As a matter of fact, however, their principal means of observation in this respect appears to be the sensitive antennæ. Having closely studied the habits of the leaf cutting ants, Atta fervens,[3] in Texas, I cannot readily think that any spider, or any other creature at all obnoxious to these ants, whatever might be its form, would have been permitted to remain in the way of the immense swarms of insects that issue in the evening from their formicary, and go forth upon their predatory expeditions into the surrounding foliage.

Form Mimicry of Animals.

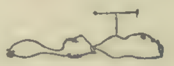


FIG. 315. An outline side view of Simonella americana. (After Peckham.[4])

Ant like Spiders.

Another of these ant formed spiders, which belongs to our indigenous fauna, is Synemosyna formica Hentz. (Fig. 316.) The figure is drawn from a specimen sent me by Professor Peckham, but the species is quite widely distributed over the United States, having been originally described by Hentz. Yet another spider which certainly bears a striking

[1] Ann. Soc. Entom. de France, 1889, page 220, plate i., Fig. 3.
[2] Spiders of the Subfamily Lyssomanæ, Trans. Wisconsin Acad. Sci., 1888, page 252.
[3] Proceed. Acad. Nat. Sci., Phila., 1879, page 33.
[4] Proceed. Nat. Hist. Soc. Wisconsin, 1885, plate i., Fig. 1.

resemblance to hymenopterous insects, is drawn from a specimen sent me by Professor Peckham, and was collected in South America. (Fig. 317.) I do not know the particular genus to which this species belongs. The number of species having this characteristic form appears to be quite limited in any given locality, particularly of temperate climates; but there are probably many more than has been supposed, for Professor Peckham informs me that he has at least seventy-five species in his private collection.


Fig. 316. An Ant spider, Synemosyna formica Hentz.

According to Mr. Cambridge, the most striking instance of resemblance among British spiders is that of Micaria scintalans, found in some abundance in the Isle of Portland. This spider so nearly resembles a large ant which abounds in the same locality, that it requires the second look of even a practiced eye to be sure whether it be really spider or ant. The advantage, or "protective effect," afforded to one thus resembling another is not always easy to be understood at once. It may often consist in the protection from certain dangers to which the creature resembled is either not liable or may be specially guarded against. Thus the ants of Portland, being of a hard and horny nature, may not be a favorite food for those enemies which would find an agreeable morsel in the softer and more succulent spider. The latter, therefore, would deceive, and so escape such enemies, from its resemblance to the distasteful ants. In other cases (and, possibly, also in the one just mentioned) Cambridge thinks the resemblance may give the resembler a chance of obtaining its prey more easily. Thus, in the south of Africa there is a spider resembling an ant even more closely than the Portland species. The habit of this ant is to feed on honey dew along with multitudes of insects of other orders. These latter have no dread nor suspicion of the ants, which, in fact, have a common object in view, and do the other insects no harm. But then, under cover of the close resemblance to the ants, come the spiders, who, unsuspected and unresisted, regale themselves at their leisure upon the defenseless insect.

A British Specimen


Fig. 317. An ant like spider from South America.

Having recorded the facts, it may be well to consider some of the theories advanced to account for them. In general, it may be said that this mimicry is considered as protective. Its use is, first, to enable the mimic to more readily obtain necessary food among its natural prey; or, second, to protect it from natural enemies, particularly (as in this case of form mimicry) from some enemy that especially threatens its existence. Darwin applies to these analogical resemblances, or adaptive resemblances, as he calls them, his theory of natural selection. He

Darwin's Theory.

cordially adopts the opinion expressed by Mr. Bates concerning the remarkable mimicry between the genera of butterflies, Ithomia and Leptalis, as they are found in Brazil.[1] Mr. Bates concludes that the Leptalis first varies, and when that variety happens to resemble in some degree any common butterfly inhabiting the same district, this variety, from its resemblance to a flourishing and little persecuted kind, has a better chance of escaping destruction from predaceous birds and insects, and is consequently oftener preserved, the less perfect degrees of resemblance being from generation to generation eliminated, and only the others left to propagate the kind.

In this connection Mr. Darwin remarks: "Insects cannot escape by flight from the larger animals, hence they are reduced, like most weak creatures, to trickery and dissimulation."[2] In what sense can it be true that a resemblance in form, which must be the result of influences operating upon the very germ of life, acquired by and transmitted from ancestors, is traceable to the volition of the creature, and is an act of deliberate "dissimulation and trickery"? Whatever may have been the origin of adaptive resemblances, certainly at the outset we may exclude any such supposition as this. In the nature of things the cause of structural resemblance is beyond the individual control of the mocking or mimicking species.

Ant like Forms.

The most striking example of the mimicry of animal forms among spiders, as has been said, is that of Ant spiders, of which Simonella americana is an example. The theory which accounts for this on the hypothesis of natural selection supposes that, through the natural tendency to vary, a spider in a brood acquired a slight resemblance to an ant. This slight resemblance protected the spiderling so much as to give it an advantage over its fellows during the attacks of birds that feed upon spiders, but do not feed upon ants. This protected individual, having matured, transmitted its peculiarity to offspring, some of whom, by the same tendency to variation, exaggerated the ant likeness; and so, by infinitesimal increments, in the course of time Simonella americana and other species more or less closely resembling ants were produced.

Value of Slight Variation

Concerning this theory it may be remarked, first, that the real difficulty seems to be in the supposition that such a slight variation as is supposed could possibly be of any advantage to an individual spiderling in the midst of a large brood. The dangers to which these are exposed are not chiefly from birds. They are very small, soft bodied creatures, exposed to many perils. As soon as they set up housekeeping, and even before it, they are preyed upon by their own order, for large spiders unceremoniously eat little ones, and small spiders eat less ones. Among Wanderers like Simonella and other Attidæ, the

[1] Bates, "Naturalist on the Amazon."

[2] "Origin of Species," Chapter XIII., page 386.

young stay with the mother until they are somewhat grown, and then have shelter beneath rocks or other secluded positions where birds are not apt to find them, although, of course, some birds do mouse around and pick up insects in the most secluded spots. I imagine, however, that the dangers threatening young Attidæ are much greater from certain insects and individuals of their own order, than from birds. I can, therefore, hardly conceive what advantage it would be under such circumstances for the spider to resemble an ant, even if we were to suppose that such a minute resemblance as the hypothesis requires at the outset, would be of advantage in any case. In point of fact, the theory is not workable, as it seems to me. Any change of form to be effective must occur in the first stages of life. But a minute resemblance could be of no advantage, as the discriminating powers of enemies, whether insects, birds, or spiders, are hardly so acute and delicate as to make an infinitesimal variation of much importance in screening one individual spiderling in the midst of a brood. In short, if we are to suppose that the birds are the real enemies, or any other creature that is indisposed to feed upon ants, it seems necessary, in order to justify anything like this theory of the origin of mimicry, to suppose that the variation of the spiderling was, at the outset, so great as to give it at least a reasonable likeness to the ant.

Sight of Birds.

The theory takes for granted an accuracy of eyesight on the part of birds that close observers will scarcely be willing to admit. How far can birds distinguish color? This is a question which has scarcely yet been fully solved. How far can insects distinguish color? How far can birds and insects distinguish between such minute variations in form as that which the above theory seems to require? In accounting for the origin of cocoon mimicry we suppose that the eyesight of birds and wasps is so defective as to form and color as to permit them to be deceived by a difference as little marked as that which exists between the cocoon of the Tailed spider, for example, and the spider herself. But, in accounting for the mimicry of ant like forms, we are compelled to reverse this attitude, and suppose the eyesight of birds and raiding wasps to be so accurate that it can distinguish between a slight variation on the part of one spider of a brood towards an ant, and the normal form of other spiders of the brood, and distinguish so accurately that it will avoid the ant resembling spiderling and take others. Whatever theory of the origin of mimicry we adopt, certainly must be free from inconsistencies such as this.

Moreover, the greatest destruction, as far as I am aware, wrought by birds upon young spiders is accomplished under circumstances that preclude any such an element as above. Immense numbers of spiderlings, including, I believe, all species of Saltigrades, possess the aeronautic habit, and while they are flying through the air upon their tiny mimic balloons they are devoured by swifts and swallows, who skim the air and gather

these flying spiders into their crops, where they have been found in quantities. Certainly, a resemblance of an ant form could be of no avail here.

Again, the theory compels us to assert that ants are not subject to destruction by birds. Of course, unless this be true we can conceive of no advantage in the mimicry of an ant form as protecting the spider against birds that seek to devour it. Its safety lies in the fact that it is covered from harm by its likeness to an insect which birds avoid. On the contrary, I know that some birds certainly do eat ants, and eat them greedily.

Birds Eat Ants.

Mr. Carl Voelker, of Carlingdale, Delaware County, Pennsylvania, is a taxidermist of large practical experience, and with a fondness for natural history which prompts him to make and note observations upon the general habits of birds and other animals. He has informed me that the flicker, Picus auratus, at certain seasons of the year—in the spring, for example—will station itself upon a dead stump, which in our American woods is frequently infested with ants, and feed greedily upon them as they pass to and fro. This he has observed many times, and believes that at certain seasons this bird lives entirely upon ants. He has seen two species devoured by them in the manner above described—a little black ant and one about twice as large.

The pileated woodpecker, Picus pileatus, feeds quite habitually upon the large black Pennsylvania carpenter ant, Camponotus pennsylvanicus. He has frequently taken these insects, in various stages of decomposition, out of the crops of these birds, at one time having counted nearly seven hundred in the crop of a single woodpecker. The bird not only takes the ants in the summer, but also in the winter, and Mr. Voelker has seen them stationed upon trees, pecking at the gangways or gates into the formicaries until they had been hammered open, and then extracting the ants while they were in a torpid state. As some of these homes in forest trees are extensive bits of architecture and are inhabited by vast numbers of insects, the amount of food thus obtained must be considerable. In the forests of Pennsylvania I have seen formicaries of the carpenter ant six feet in length and occupying the entire central part of a goodly sized tree or branch.

The European woodpecker, Picus ater, according to the same gentleman, who has observed the same species in Germany, subsists entirely upon ants, and the same fact is true of another European species, Picus virens, popularly known as the Grass Woodpecker. Mr. Voelker has seen this bird on the hills of Germany digging into the soil, and feeding eagerly, not only upon the larvæ, but upon the ants themselves.

The Woodpecker.

It is generally known that the ordinary barnyard fowl will devour ants without hesitation. Mr. Voelker states that once he was engaged in the woodyard of his country residence in breaking up a log of decayed wood

which had served as a formicary for a large colony of ants. The insects with their larvæ and pupæ were scattered over the ground, and the chickens, getting scent of the game, flocked one after another from the barnyard in such numbers and with such greedy persistence that he had to cease his labors out of regard to the safety of his fowl. The chickens devoured the larvæ and pupæ and the ants.

The same gentleman says that he has found particles of ants in the stomachs of grouse, although it is possible that they may have picked up the ants while feeding upon the larvæ, which latter may have been the chief object of desire. The various song birds of America, as the mockingbird, catbird, thrushes, etc., eat the larvæ of ants, as is well known, but Mr. Voelker had never discovered particles of the ants themselves in their crops.

Other Birds.

Mr. T. B. A. Cockerell[1] notes that Dr. Riley records that sparrows (Passer domesticus) feed on certain Aculeta, Halictus, Typhia, Myzine, and ants. Mr. Cockerell himself had found ants in the stomach of Sialia arctica shot in Custer County, California. The stomach of a woodpecker shot by Rev. A. Wright in the same locality contained a number of ants, the majority apparently Formica fusca, with a few of Formica integra.

I can certify by my personal observations, as well as by reports of others, that some of the native birds of Fairmount Park (Philadelphia) feed upon colonies of Formica integra, which are found in the neighborhood of Rockland on the Schuylkill River and elsewhere. It is well known that birds of all kinds are fond of "ant eggs," by which popular name is meant the pupæ of those ants whose larvæ enclose themselves within a cocoon. These ant pupæ are gathered in immense quantities from the mounds of Formica exsecta, F. fusca, F. rufa in various parts of Europe, and are regularly sold in the markets as food for pet birds. These eggs, if nothing else, would invite the attack of birds upon ant hills, and would thus lead directly to devouring the ants themselves, who invariably rally to defend their nurslings.

English Game Birds.

Certain game birds are extremely fond of ants. In the summer of 1887, while visiting Mr. E. C. Cornwallis at Linton Park, Kent, England, I was taken by my host to the gamekeeper's lodge, on the grounds of which several hundred, perhaps a thousand or more, young partridges were being raised for the purpose of stocking the shooting park. These little fellows had been hatched out under barnyard fowl, and were, when I saw them, turned loose upon a bit of sloping ground that was literally honeycombed with the nests of a small species of ant, apparently a Lasius. The whole slope had been torn up in order to procure these nests as food for the young partridges. Mr. Cornwallis gave

[1] Entomological News, Philadelphia, May, 1890, page 65.

a peculiar whistle, which was at once recognized by the flock of chickens, who hurried together at the call, as tame birds always do when summoned to feed. The gamekeeper tossed them several bits of sod containing ant nests, which the birds attacked, tore in pieces, and in a moment had devoured all the insect contents. Simonella americana is not much larger than these ants, and certainly there would be little protection from such voracious creatures as these in the mimicry of ant forms. I have no doubt, although I cannot speak positively, that our American quail are equally as fond of ants as these English partridges; and as they are ground birds, their habits of feeding would make them destructive enemies of all ant species burrowing in the earth.

The Pittidæ.

Again, it is well known that in the warm districts of South America, and in other parts of the earth, there is a family of birds who are such persistent destroyers of ants that they take their family name from this habit, and are known as the Formicariidæ.[1] These ant thrushes, Pittas or Pittidæ, are also an Old World group, being found in the Malay Islands. The Great ant thrush, which is also called the Giant Pitta, is a native of Surinam, and is a bird about the size of the English rook.[2]

I have heard, although I cannot now cite the authority, that in Africa, when the Driver ants go out upon their excursions, during which they will prey upon all sorts of insects and small vertebrate animals, ant thrushes, or some species of ant devouring bird, hover over the raiding column, upon which they make their assaults, devouring immense numbers of the drivers.[3] Such are some of the facts which have fallen to my notice, or under my eye; and while it is probably true that some birds avoid ants as articles of food, I imagine that nearly all animal feeding birds will pick them up whenever they have an opportunity. Such being the case, we can hardly admit the force of an argument which is based upon the supposition that the form of an ant would protect a spider, or any other creature, on account of the disrelish of birds for ants.

Are Wasps Mimicked?

If we were inclined to accept the theory of natural selection, as above outlined, as an origin for mimicry of ant forms, it would seem to me more rational to suppose that the particular enemy against which the mocking form is protected, is not the bird, but the wasp and ichneumon fly. My chapter on the Enemies of Spiders shows what depredation is wrought among araneads by various members of the wasp family. As far as I know, wasps do not interfere with each other, or with ants, who closely resemble them, being, in fact, members of the same order of Hymenoptera. Anything that would

[1] Alfred Wallace, "Geographical Distribution of Animals, Vol. II., page 296; Wright, "Animal Life," page 271. [2] "Wood's Natural History," page 341.

[3] I think that this, or a similar fact, was told me by an African missionary to the Congo region.

be likely to deceive these inveterate spider enemies would undoubtedly be a protection to spiders of all tribes.

But then, with such a theory in mind, we are met at once by the fact that those spiders which are most frequently found within the clay cells of mud dauber wasps, and those which these insects most frequently collect as food for their larvæ, are the Sedentary groups such as Orbweavers and Lineweavers. They do indeed take the Thomisoïds, especially those that lurk on flowers in pursuit of prey, and which, in turn, sometimes capture the wasps. The Saltigrades are also taken; but if I may judge from my own observations, they are least numerously represented of all the tribes except perhaps the Lycosids and the Tunnelweavers. This seeming immunity is evidently not due to any likeness of Attidæ in general features to wasps, but simply to their manner of life, which, in large measure, screens them from assault, and enables them to escape. Now, the question must rise in considering such a theory, why does not natural selection operate for the protection of those spiders which obviously need protection the most?

Is it not remarkable that during all the ages in which the forms of Orbweavers have remained substantially unchanged, as well as the forms of wasps, and during which period the habits of both creatures must have been the same, Nature has refused to work in the direction of protecting the exposed Orbweavers by providing them some analogical resemblance such as that which we remark in the case of Simonella americana? It seems to me illogical to expect a general law to account for the origin of certain peculiarities in Nature, and yet to exclude this general law or force from operation within the whole field of life with the exception of one very small section. It seems further illogical to hold that this general law would have failed to operate not only in the cases where it seems to be most necessary, but in those wherein all the circumstances are best arranged for its most effective operation.

While spiders thus abundantly prey upon ants, sometimes the conditions are reversed, for when the opportunity presents, the ants will feed upon spiders. In certain cases this takes the shape of a systematic raiding of the whole section, as, for example, according to Mr. Cambridge, the large red ant of the woods, Formica rufa, destroys spiders so completely, that in localities thickly inhabited by those insects, he had generally found it almost useless to search for spiders.[1]

Ants Eat Spiders.

Whether or not any ant like species are found among Sedentary tribes I do not know. But it entirely passes my imagination to conceive what possible advantage could accrue to an Orbweaver, for example, from resemblance to an ant. Orbweavers, and yet more frequently Lineweavers, prey upon ants; but it is not necessary that there should be any resemblance to

[1] Spiders of Dorset, Vol. I., page xxxi.

the emmet in order to accomplish the destruction of vast numbers of them, as I can fully testify. As the Orbweavers and Lineweavers do not leave their snares to capture prey and move among the ants after the fashion of the prowling Saltigrades that do mimic ant forms, the fact of ant resemblance, should it exist among them, must have a quite different solution. One could suggest, in their case, a protective value in resemblance to wasps, but none at all as against ants.

III.

Local, or Mimicry of Environment.

Another style of mimicry among spiders is resemblance to forms of objects among which they live, as with Tetragnatha extensa. This aranead has a long and narrow body, of a cylindrical shape, not unlike a small twig in appearance. Its colors are delicate green, yellow, and gray, thus increasing its resemblance to the plant. But the most striking feature of the mimicry is the habit of drawing together the four hind legs until the joints closely approximate each other, stretching them straight backward, and treating the two pairs of fore legs in the same way, stretching them out forward. (Plate III., Fig. 6.) Thus the spider is extended along the stem of the plant in a straight line, so that her body closely resembles the object upon which she lies. The habit prevails in all known species of the genus. In this case, although we concede that Tetragnatha has had no control over her own particular form and its resemblance to a small twig, we must allow that her action is a matter of personal volition, and appears to be exercised with deliberate purpose to conceal her presence. Yet, the behavior of the spider frequently compels one to wonder how the supposition of mimicry can be harmonized therewith.

Tetragnatha.

For example, the Peckhams record that a male Tetragnatha grallator,[1] when touched as he hung in the web, ran to a branch, whereon he stretched himself. In this position he was almost indistinguishable, as his color was exactly like that of the branch to which he clung. The branch was gently shaken, but instead of keeping quiet he ran a little way and then stretched out again. This he repeated, stupidly betraying himself as often as the branch was touched.[2] One would think that Nature, having taken pains to produce such a striking protective mimicry, would not have failed to make it useful by imparting a corresponding instinct that would adapt behavior to opportunities.

A Laterigrade spider, Tibellus, which has at least one quite common representative in the United States, has a habit not very different from Tetragnatha. Tibellus oblongus is abundant in many marshy places in the south of England. It has an elongated oval body, with longish legs, and is of a uniform dull yellowish hue; it is an exceedingly active spider,

[1] T. elongata Walck. [2] Mental Powers, page 411.

and, when running in autumn among the dull yellowish, decaying grass and rushes, looks much larger than it really is. All of a sudden one loses sight of it, and unless he is aware of its habits, is puzzled to know what can have become of it; but there it is close by, stretched out at full length along the similarly colored stem of grass or rush, with its first and second pairs of legs put forward in a straight line, and its third and fourth pairs stretched in the same way backwards, so as to be scarcely distinguishable from the stem itself.[1]

Natural Habit.

In the case of Tetragnatha the mimicry of the twig on which she lies appears at first sight very striking. I have no disposition to undervalue the character or protective benefit of this mimicry. But it must be remarked that, in point of fact, she simply assumes the position which she habitually takes when hanging on her web. Both this genus and Uloborus stretch themselves out upon the central part of their orb, or upon a string suspended from it, with their feet approximated in precisely the attitude above described as taken by them when they stretch along the under part of a branch. We are therefore compelled to inquire how far this attitude of Tetragnatha may be a deliberate attempt to shield herself, and how far it is the natural result of habit prompting her, when attempting to screen herself, to drop into the form natural because most common to her. The value of the form need not be questioned, but in considering its origin we are required to consider the habitual attitude of the spider upon her web as well as the attitude of mimicry upon a twig during her occasional excursions. Some other spiders have the habit of stretching themselves like Tetragnatha upon foliage and twigs, as, for example, the Orchard spider, although not to the same extent as Tetragnatha. (Plate III., Fig. 6, above.)

Mimicking Knots

The ordinary, or at least the common, position of Epeïroids, when resting outside their nests or snares, is to draw up the legs so that the two front pairs are humped up above the head and are nearly in a plane with each other and the spider's face. The hind legs are drawn up against the abdomen. The spider thus forms a little roundish bunch and as thus seen is not unlike one of the knots, warts, or excrescences frequently seen upon plants. This habit universally prevails among spiders, and one who follows their actions for a little while will be certain to observe it. Thus they remain perfectly still, and at a casual glance might be taken for a knot or other excrescence upon the bark of a tree or plant, as in the case of Epeira strix, represented Plate III., Fig. 4.

The mimicry of a wart, knot, or bud, or other natural irregularity, would seem to be quite as useful as the special mimicry of Tetragnatha, since it would be as likely to deceive the eye of a prowling enemy. In

[1] Cambridge, Spiders of Dorset.

this bunching habit spiders, Orbweavers at least, follow the influence of habit, for when at rest within their nests they almost invariably draw themselves up in the manner described. However, the position is contrary to that generally assumed by spiders making vertical orbs when hanging in wait for prey upon the orb. Then the legs are stretched backward and forward, not, indeed, in a straight line like Tetragnatha and Uloborus, but somewhat in the position of a St. Andrew's cross or the letter "x," as heretofore described.

IV.

Color Mimicry.

Color mimicry in spiders is supposed, first, to facilitate taking prey, thus promoting the life of the species, and, second, to protect the mimic from assaults of enemies, who are deceived by the close resemblance either to surrounding objects or to some animal obnoxious to the assailant. An interesting example of color mimicry is the common spider Misumena vatia. This spider is generally yellow, mottled upon the abdomen, and with darker rings on the legs. It will often be found spread out upon the yellow heart of an ox-eyed daisy, or in like position upon Coreopsis (Plate III., Fig. 1) or golden rod. Here it remains and preys on insects frequenting the plant. It certainly closely resembles the flower upon which it is ambushed, and the ordinary observer might well fail to notice its presence. On one occasion I found this species concealed underneath one of the outer petals of a half opened rose, and, curiously, it had its prevailing yellow greatly modified by a pinkish cast of color, more closely resembling the rose upon which it was lodged. (Plate III., Fig. 2.)

Misumena vatia.

Mrs. Treat gives an account of a Laterigrade that appears to be Misumena vatia, whose lurking place was in the heart of roses, and was so nearly the same shade of color as the flower as to make it difficult to see her. When the rose began to wither she took up position on a fresh one. The spider was first observed in July, and remained on the same bush about three weeks, and then moved to a bright red tea rose, whose stamens were more conspicuous and numerous than the other, and which was visited by a greater number of insects. Misumena went to the centre of one of the flowers, but the stamens were of a deeper yellow than her body, and the surrounding petals made her easy to be seen. She seemed to know this as well as the looker on, and, although more game visited these roses, she did not stay long. The observer thought the spider conscious that her safety depended upon the resemblance, and therefore returned to her old home among the petals of the light colored rose.

She made no web to entrap prey, but depended wholly upon strategy and muscular strength. When waiting for prey she cuddled down in the centre of the flower, and erected her long fore legs in such position that

it was almost impossible to distinguish them from the imperfect scattering stamens. If a wasp or humble bee alighted near her, she dropped her stamen like legs and crouched down and concealed herself as much as possible; but when these formidable insects departed, she resumed her expectant attitude.

Capturing Insects.

Now a pretty butterfly comes flitting down, all unconscious of danger. Misumena is perfectly motionless, but at the proper moment shoots out her legs and grasps the insect in fatal embrace. The butterfly is often four or five times her own weight, yet she manages to prevent her victim from mounting with her into the air, probably by holding firmly with her hind legs to the flowers.[1]

The remains of night flying moths were often observed scattered near this individual, which had evidently been captured during the night, but her most frequent game was dipterous. The fact, however, that she does prey so frequently upon night flying insects is a good indication that she is able to acquire all the food needed without the aid of mimic colors.

I quote another popular account of the habits of a spider which I take to be the same species. The description is from the pen of an intelligent observer, but not a naturalist, who simply records, with great astonishment, a first experience of a hitherto unknown fact, and therefore without any predisposition to see a case of mimicry in a casual resemblance. The account is taken from a description of a walk in the vicinity of Media (a few miles from Philadelphia), and was published in a Friends' educational journal.[2]

Mimicking Wild Flowers.

"In Bare Hill meadow was a garden of flowers such as no man ever planted or ever shall. Asters, Golden rods, and Compositæ generally, were massed in such profusion that the meadow was like Joseph's coat, of many colors and bright ones. In some places the herbage was higher than our heads, and passage through it was difficult. Over all towered the spires of the purple Boneset or Queen-of-the-meadow, so beautiful and graceful when seen thus, so coarse and clumsy when examined closely. On a head of this species, and among its purple flowers, we noticed a little purple spider with oval body and peculiar markings. So closely was the color of the spider adapted to that of his dwelling that we should have overlooked him entirely if he had not moved.

"Shortly we found on the white panicle of the Boneset proper a spider similar in size, shape, and markings, but pure white in color. We then examined the Golden rods and found a third similar spider thereon of a yellow color. A close examination of our flower garden revealed a number of these variously colored insects, each simulating the color of its habitat.

[1] Mrs. Mary Treat, "My Garden Pets," page 13.

[2] "The Student," Philadelphia, Fourth Month, 1889, page 335. "The Banks of Crum," L. Chalkley Palmer.

PLATE V.

SOME HYMENOPTEROUS ENEMIES OF SPIDERS.

1, EURYPELMA HENTZII. 2, PEPSIS FORMOSA. 3, ELIS 4-NOTATA. 4, PEZOMACHUS MEABILIS. 5, PEZOMACHUS DIMIDIATUS. 6, PEZOMACHUS GRACILIS. 7, CHALYBION CÆRULEUM. 8, TRYPOXYLON POLITUM.

it was almost impossible to distinguish them from the imperfect scattering stamens. If a wasp or humble bee alighted near her, she dropped her [illegible] as much as possible, but when these formidable insects departed, she resumed her expectant attitude.

Now a pretty butterfly comes flitting down, all unconscious of danger. Misumena is perfectly motionless, but at the proper moment throws out her legs and grasps the insect in fatal embrace. The butterfly is often four or five times her own weight, yet she manages to prevent her victim from mounting with her into the air, probably by holding firmly with her hind legs to the flowers.[1]

The remains of night-flying moths were often observed scattered near the individual, which had evidently been captured during the night, but her most frequent game was diurnal. The fact, however, that she does prey so frequently upon night-flying insects is a good indication that she is able to acquire all the food needed without the aid of mimic colors.

I quote another popular account of the habits of a spider which I take to be the same species. The description is from the pen of an intelligent observer, but not a naturalist, who simply records, with great astonishment, a first experience of a hitherto unknown fact, and therefore without any predisposition to see a case of mimicry in a casual resemblance. The account is taken from a description of a walk in the vicinity of Media (a few miles from Philadelphia), and was published in a Friends' educational journal.[2]

"In [illegible] Hill meadow was a garden of flowers such as no man ever planted or ever shall. Asters, Golden rods, and Compositæ generally, were massed in such profusion that the meadow was like Joseph's coat, of many colors and bright ones. In some places the herbage was higher than our heads, and passage through it was difficult. Over all towered the spires of the purple Boneset or Queen-of-the-meadow, as beautiful and graceful when seen thus as coarse and clumsy when removed [illegible]. On a head of this species and among its purple flowers we noticed a little purple spider with oval body and peculiar markings. So closely was the color of the spider adapted to that of his dwelling that we should have overlooked him entirely if he had not moved.

"Shortly we found on the white panicle of the Boneset proper a spider similar in size, shape and markings, but pure white in color. We then examined the Golden-rods and found a third similar spider thereon of a yellow color. A close examination of our flower garden revealed a number of these curiously colored insects, each possessing the color of its habitat

Misumena Ambushing Wild Flowers

[1] Mrs. Mary Treat, "My Garden Pets," page 18.

[2] "The Student," Philadelphia [illegible] "The Banks of [illegible]" J. Chalkley Palmer.

PLATE V.

SOME HYMENOPTEROUS ENEMIES OF SPIDERS.

1, Eurypelma hentzii. 2, Pepsis formosa. 3, Elis 4-notata. 4, Pezomachus meabilis. 5, Pezomachus dimidiatus. 6, Pezomachus gracilis. 7, Chalybion cæruleum 8, Trypoxylon politum.

It would be strange if all these were one species, differently colored according to the place they dwell in, and having power to change from purple or white to yellow at will; yet this seemed probable to us. Or was it that a species had developed these different varieties, each adapted to live on a certain plant? However this may be, the arrangement evidently resulted in a twofold advantage, in that it enabled the spiders to escape the peering eyes of birds, and at the same time to lie in wait unperceived for the insects of various sorts that frequent such flowers in great numbers. In no case, it may be added, did we see a purple spider on a yellow flower, or vice versa."

The English Species.

Mr. Cambridge has observed and recorded like facts of Misumena vatia in England.[1] He says: "I find this spider very commonly in the blooms of the great mullein, Verbascum thapsus, to which the pale yellowish hues of the spider are well suited for its concealment in the yellow blossoms. An allied spider, Thomisus onustus, found on the heather blooms, and upon some other pink flowers, is beautifully tinted with pink, chiefly in its younger and feebler stages. The Rev. C. W. Penny (of Wellington College, Wokingham) tells me that he has found examples of this spider on yellowish blossoms, and that these examples are generally of a yellowish hue, quite devoid of the pink color of those found on pink blooms. I am inclined to think that this is not invariable, inasmuch as I have found here the more mature examples, which are generally devoid of pink coloring, also on the pink heather blooms. The protective resemblance of color would not be so necessary, in the above instance, for the protection of the more mature as for that of the younger spiders, and therefore we might expect to find the former on flowers of any color growing where the spiders are found; while I have certainly only met with the younger pink colored spiders on the pink heather blossoms." It is important to note the above exception as to adult forms.

Most other Laterigrade spiders known to me are of a dull gray or brownish color. As they are frequently found resting upon the bark of trees, over which they prowl seeking their natural prey, their resemblance to the color of the bark is quite striking, and might serve to protect them alike from the observation of enemies and of victims (Plate III., Fig. 3.)

Mimicking Bark and Ground.

Among the Citigrade or ground spiders, the same fact may be noted. Their colors are generally neutral or dull grayish, mottled or striped with black. They thus blend easily with the colors of the ground and stalks of plants and grasses among which they frequently move. Some of these spiders when found in littoral sites take upon them the color of their surroundings. For example, the Turret spider, which I have observed along the seashore from

[1] Spiders of Dorset.

Cape Ann southward, burrowing in her characteristic perpendicular holes, has in such sites a color quite corresponding with that of the white sand in which she dwells.[1] The same species taken further in the interior is found of a darker hue, thus resembling the soil in which it lives. This would appear to be a decided example of the adaptation of color to environment, or, as better stated, the influence of environment upon color.

Cambridge refers to like facts as marking English species. A Laterigrade, Xysticus sabulosus Hahn, so exactly resembles both in form and color the little bits of gret, yellowish black, and red brown mottled stone, found on the bare patches where turf has been pared off the heaths, that until the spider moves it is almost impossible to detect it. Lycosa herbigrada, a gray spider marked with black and brown markings, is another instance of exact adaptation to the gray, sandy heaths where it occurs; while Philodromus fallax is equally well concealed by the perfect adaptation to the coloring of the dull yellowish, sandy spots where alone it is met with. The common and beautiful English Epeira cucurbitina, found on rose and other bushes, in gardens and woods, is of a clear, bright green color with a brightish red spot at the hinder extremity of the abdomen; this spider, when, as it often does, it sits tucked up between the green shoot and the axil of the leaf, looks exactly like a young bud just ready to burst.[2]

Natural Selection.

Mimicry and the survival of the fittest have been suggested to account for this interesting habit. It is argued that those spiders, among the numerous broodlings hatched out from the eggs, whose colors most closely resemble those of the flowers alluded to above, are the ones which survive, by reason both of the degree of protection against enemies derived from their likeness to colors of the flower, and their facility to capture prey because of the same resemblance, which would naturally conceal their presence. In other words, those spiderlings which by any chance happen to find lodging upon yellow flowers, or flowers most closely colored like themselves, are the ones which survive the perils of spider babyhood and grow to adult age.

Difficulties.

Before one fully accepts this theory it will be well to consider certain difficulties. The most perilous age of spiders, as is well known, is that which immediately follows exode from the cocoon. In a multitude of cases in which these little ones entered life far removed from any flowers corresponding with their normal color, how are we to account for their preservation? Certainly they did live and retain their natural colors in spite of the absence of golden rods, black-eyed Susans, ox-eyed daisies, and flowers of like hue. Moreover, one is compelled to establish the fact that the opening up of these flowers cor-

[1] See my notes on "The Turret Spider on Coffin's Beach," Proceed. Acad. Nat. Sci., Phila., 1888, page 333. [2] Spiders of Dorset.

responds with the entrance of the little fellows into life, and that the period of flowering is contemporaneous with their growth. It seems necessary, in order to sustain consistently the theory of survival, that a yellow spiderling should have a yellow environment from the outset, and that a white and pink spider should have a corresponding site from exode to maturity. But, in point of fact, when we find the adult Misumena upon a half opened rose, as in the cases above mentioned, we know that the rose was opened up but yesterday, whereas the spider must have been several weeks in maturing. This is true of all cases, or certainly of most cases, in which we find adult spiders domiciled or ambushed upon flowers. We are therefore compelled to the conclusion that the color did not nourish the spider by providing for it a protective site, but that the spider sought the flower and settled upon it, either accidentally or of choice.

Epeira parvula.

Epeira parvula is a spider remarkable for the variations it presents in the dorsal markings of the abdomen. It is widely distributed throughout the United States from ocean to ocean, and everywhere has the same characteristic. I have usually found it upon its orb waiting for prey, but like other Epeiras it undoubtedly rests upon adjacent objects. The Peckhams cite this species as an example of protective resemblance in spiders.[1] It is a common spider in Wisconsin, and the Peckhams most frequently saw it on cedar bushes, where its color harmonizes with the color of branch and fruit. During the day it usually rests on the branch near its web. The back of the abdomen is a peculiar bluish green, exactly like that of the lichens growing on tree barks. The bluish color is broken up by waving black lines, which imitate the curling edges of the lichens. I reproduce the drawing given by the Peckhams to illustrate this resemblance. (See Plate III., Fig. 5.) Undoubtedly, the resemblance in this case is striking, but I take it to be simply an accident of the situation. Parvula is found everywhere and upon all sorts of foliage, even where cedar bushes and lichens are not found. It is necessary to remember this, although, of course, it does not gainsay the fact that among Wisconsin cedar bushes it may have received some benefit from the resemblance which the Peckhams note.

Metallic Colors.

The suggestion has been raised that there may be some protective value in the brilliant metallic colors which are possessed in a high degree by some species of spiders. I have no observations to offer on the subject, but quote a remark of Mr. A. G. Butler, of the Kensington Museum. He says that metallic colors are not a source of protection from birds, as birds know nothing of the nature of metal, and whatever is brilliant and shining they make for at once, to see whether it is good to eat.[2]

[1] Observations on Sexual Selection, page 83. [2] Jour. Royal Micros. Soc., 1889, page 633.

V.

Examples of cocoon mimicry are furnished by certain American Orbweavers, as, for example, Cyclosa caudata and Cyclosa bifurca. These spiders make cocoons which in general shape and color closely resemble the mother. The cocoons are hung in a connected series within the orb, a rather exceptional disposition. The mother clings to the lower cocoon of the string, and might easily be confounded with her cocoon. The conical shape of Caudata's cocoon is paralleled by the compressed apex of her abdomen, which has given her the name of the Tailed spider. Her color also, a grayish white mottled with blackish markings, increases the resemblance between her and her egg sac, which is composed of whitish silk covered over with the scalpage or débris of slaughtered insects. Cyclosa bifurca is colored green, and her cocoon has a greenish hue. (See Plate IV., Figs. 10, 11, 12.)

Cocoon Mimicry.

The suggestion has been made that placing cocoons of this particular form within the limits of the spider's snare, has a tendency to deceive attacking insects, such as raiding mud dauber wasps or arachnophagous birds. Professor Peckham alludes to the fact that Caudata, when a vibrating tuning fork is placed near her, instead of remaining steadfast upon her snare, drops from it in the way common to Orbweavers, and thus betrays her position and exposes her person.[1] The implication is that, were the resemblance really protective, the spider would have held steadfast and not acted as she did.

On the contrary, it seems to me that this fact does not really break down the force of the suggestion that such mimicry may be protective. For we must conceive that a raiding bird or wasp, if deceived at all by the appearance of the cocoons hanging in the snare, would flutter from one cocoon to another until at last the spider would be reached at the end of the string. The vibration of the wings of a bird or insect would be the spider's warning of the nearness of an enemy, and her chance of safety would certainly be to drop from her web at once. Of course, if the assailant should first strike the spider herself her opportunity to escape would not be great; but supposing that there is about an equal chance that the assailant would strike one of the cocoons, thinking it to be a spider, in that case the mother has a fair opportunity to escape, and her chances are in proportion to the number of cocoons in the string. Mr. Peckham's experiment, therefore, instead of showing against the suggestion that the cocoon mimicry is useful to Caudata, seems to me to be entirely in harmony with it.

Cyclosa caudata.

In this connection it is to be noted that the young of Caudata are in the habit of hanging upon their orbs little puffs of silk closely resembling

[1] "Mental Powers of Spiders," page 395.

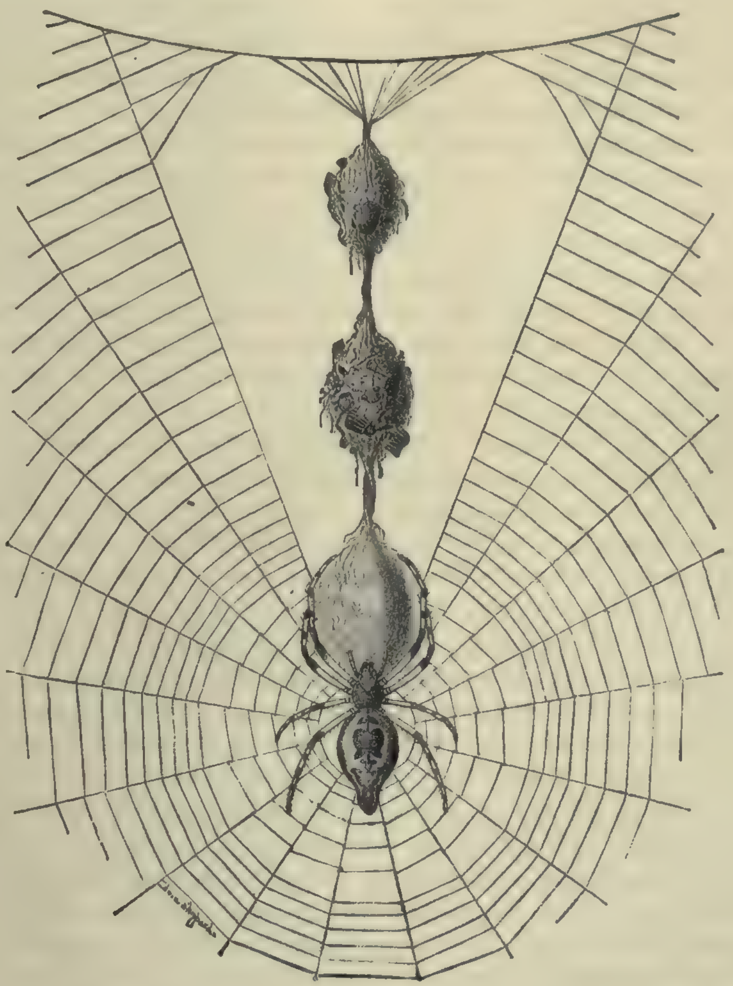


FIG. 318. Cyclosa caudata and her string of cocoons. The two upper cocoons are covered with insect débris.

the cocoons of an adult mother, and in the same position upon the orb. These cocoons are also covered with the disjecta membra of minute insects killed by the spiderlings. How shall we account for this strange imitation of a maternal habit by the young? Are these puff balls "dummies"? Is their purpose to deceive assaulting enemies, and thus protect their maker? I know no examples of a similar habit, except certain Gasteracanthas, that sometimes spread like objects at various points upon their webs, and a single case of Acrosoma rugosa, whose orb I found to be decorated in like manner.

Young Mimics.

Fig. 318 represents Caudata, much enlarged, clinging to a new made cocoon, while two others hang above, covered with the disjecta membra of slain victims. In nature the cocoons are often much more thickly covered than here shown. A slight viscidity of the silken fibre of the sacs evidently assists this habit, although the scalpage is tied or lashed to the surface by minute threads. By the time the maternal cares of the spider are ended, if the season be one fruitful of insects, not only all the cocoons, but the connecting parts of the supporting string, will be hung thickly with this ghastly crop.

Dr. Martin Lister[1] observed the habit in Cyclosa conica, a European species that corresponds closely with our Caudata, of thus stringing the débris of its prey along the central vertical line of its snare. In attributing the act to a sort of "pride of the chase" (venationis gloriola), he gave a reason perhaps as near the truth as some other theories. It is at least sufficiently startling to find in the habits of an aranead such a striking analogue of the customs of our savage human fellows who decorate their persons, lodges, and villages with the scalps and skulls of the unhappy victims of war and cannibal feasts. I am inclined to believe that the habit is for the most part protective of the young, being intended to guard the egg sac from the assaults of parasitic enemies. If so, it is a convenient substitute for chopped straw, mud, gnawed wood, etc., with which other araneads defend their eggs from enemies. But it has the disadvantage of depending wholly upon the somewhat uncertain chances of the chase. These chances, however, are the best, and indeed the only ones at her disposal. The habit of suspending her cocoons within her viscid orb well nigh estops her from descending to the ground or adjoining plants to procure dirt or chippage, as species can readily do that attach cocoons to various surfaces. I have seen only one case in which Caudata's cocoons appeared to be daubed with particles of mud. The general and special habits are thus happily harmonized.

Scalpage.

In addition to this the habit may also serve as a protection to the spider herself. At all events, as she hangs at the tip of one of these ornamented cocoons she is with some difficulty distinguishable from them,

[1] Hist. Animal Angl., page 33, 34, Tit. 4.

since the colors of her body, as well as its shape, correspond well with the colors of the egg sac. We might, therefore, regard this as a case of protective mimicry. This scalpage is never in the shape of reserved stores of food, as Lister seems to think, and therefore cannot be cited, as by Kirby and Spence,[1] to show that Conica is "more provident than its brethren." Those distinguished entomologists should have known that spiders do not feed upon the hard shells of dead insects.

Protective Resemblance.

This mode of disposing of the fragments of her feasts is not limited to Caudata's cocoons. Like her English congener Conica, as described by Lister, she hangs those remnants upon her snare. I often see orbs through the middle of which are stretched, above and below the hub, a perpendicular ribbon of open fibre. Along this will be attached two or three little conical balls above and below the hub (see Fig. 319), composed of the members of dead insects cut into fine particles and lashed together by threads. May we venture to suppose that this also is a case of mimicry, that is to say, a purpose to set up "dummies" to distract the attacks of hymenopterous and other enemies from her own person?

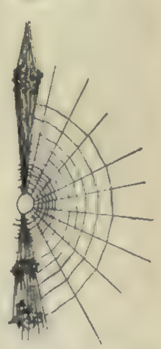


FIG. 319. Balls of insect debris in Caudata's snare.

I have met a like behavior in Acrosoma rugosa. The web was a small one, five inches in diameter, spun between the branches of a fir tree. Around the margin the remains of seven flies were threaded, much in the fashion above described. Three of these were above and three below the centre. They appeared to be mere shells, not fresh insects trussed up for future use, as one often sees when flies are plenty. They had not simply become thus entangled when cast out from the web, for three of them were fastened above the centre, at which the spider sits, and the four below were arranged along the arc of a circle in such order and position as to indicate design. I never met this peculiarity in the snare of Rugosa except in this one case, and have not observed anything like it in any other species. As a habit it exists in Caudata alone.

Acrosoma rugosa.

The young of Caudata, as I have frequently noticed, have precisely the same curious habit that marks the adults, to string along the central band of their webs fluffy, loose bunches of silk, covered with little particles of trapped insects, which increase in size as she grows. Mrs. Mary Treat has observed the same habit.[2] The transmission and early possession, in full force of such an exceptional and remarkable habit, is peculiarly noteworthy, and, except on the theory of protective mimicry, it perhaps would be difficult to suggest any useful purpose in the habit. A gentleman

[1] Introd. Ento., I., 421. [2] "My Garden Pets," page 42.

friend, who heard this statement, suggested that the spiderlings might be "playing mother" and dandling their rag baby cocoons as our children do their dolls!

Since the spiderlings thus have the habit, it may perhaps be considered as primarily for personal protection, and it is interesting to find it transferred to the protection of the cocoon. Or, if we suppose that the habit arose primarily to protect the cocoon, it is even more interesting to think that it has been carried over by heredity to the young for their own protection. It is impossible not to suspect that this habit may have arisen from the prevalent custom of trussing up newly caught flies for food.

In the cases of Cyclosa caudata (Fig. 318) and Cyclosa bifurca (Plate IV., Figs. 10 and 11) one must allow a striking resemblance between the general appearance of the cocoons and the mothers who make them. But when one comes to inquire if the like resemblances prevail generally among spiders, he finds that these two species, and a few others, stand in a small group by themselves. As shown in the preceding chapter on Color, there is little resemblance between the great majority of spider mothers and the cocoons which they make, either in general shape or color.

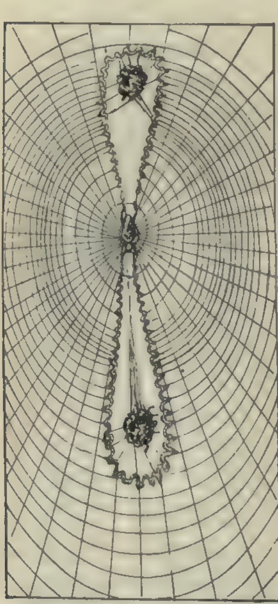


Fig. 320. Collections of insect débris in the orb of a young Cyclosa caudata.

However, it must be remembered that the value of cocoon mimicry would naturally be limited to those species which hang their cocoons in or upon their snares, and to those which brood their cocoons or watch upon or near them while the young are being hatched. Of course, there would be no utility in such a resemblance in species that make their cocoons and forthwith abandon them or die. Nevertheless, if we glance over the list of mothers that hang their cocoons in their snares, it becomes apparent that even with them cocoon mimicry must be limited. Argyrodes trigonum, as she hangs bunched in her retitelarian web (Fig. 109, page 113), might be said to have some resemblance to her basket shaped cocoon. The familiar Theridium tepidariorum is also a good example of resemblance between a mother and her cocoons, both in general shape and color. (See Chapter V., page 112, Fig. 107.)

Uloborus plumipes is not unlike her cocoons as she hangs with bunched and elongated legs beneath her orb. (See Fig. 104, page 109.) In fact the Peckhams cite this species as an example of deceptive resemblance.[1] In Wisconsin these observers found Uloborus invariably

[1] Observations on Sexual Selection, page 76, pl. iv.

building in dead branches, where its wood brown or grayish color resembles small pieces of bark or bits of rubbish entangled in deserted webs. They also perceive a case of cocoon mimicry in her habit of so disposing her grayish cocoons along the web as to look like a mass of rubbish. The protective resemblance in this species, therefore, is twofold: that of the spider to particles of dead wood entangled in its snare, and to the dry branches among which the snare is spun; and again, that of the spider to her cocoon. When Uloborus is found, however, as I often have found it, in the midst of green laurel bushes or other verdant environment, the fact of a protective resemblance disappears. If we concede the cause of mimicry as urged by the Peckhams, we must go still further, it seems to me, and suppose that the spider is endowed with a power, in one locality, which forsakes her in another, and it may be a nearby one.

Theridium serpentinum[1] (Fig. 108, page 112), with her glossy brown colors, can scarcely be considered as bearing a striking resemblance to the snow white cocoons which she hangs within her snare; and Epeira labyrinthea (Fig. 85, page 100) can by no stress of imagination be reckoned as bearing a resemblance to her cocoons.

[1] This species Dr. Marx catalogues as a synonym of Teutana triangulosa Walck. "Catalogue of the Described Araneæ of Temperate North America," Proceed. U. S. Nat. Mus., 1890, No. 782, page 521.

CHAPTER XIII.

ENEMIES AND THEIR INFLUENCE ON HABIT.

We have considered the means by which maternal instinct secures the life and growth of the spider young. It is necessary to study the natural methods by which excessive reproduction is held in check, for Nature presents to the observer a more or less continuous series of favoring and adverse circumstances, a " balance of power," so to speak, by which on one hand life is protected, and on the other is devoted to destruction. In each case there is equal regard for the common good and the general harmony of Nature.

I.

Diversified Perils

The perils which beset the spider are many, serious, and diversified. They besiege the very gate of being and cease not their relentless vigil until the coveted life has been yielded. The "natural death" of the aranead is a violent one; comparatively few spiders, perhaps, outside of those mothers who perish from inanition shortly after the act of cocooning, have any other. It is this fact which compels the great fecundity of the female, inasmuch as otherwise the species could not be preserved.

It is possible for one to conceive how the protective habits which have been heretofore described might have gradually resulted from the mother's struggle with her own enemies and those of her progeny. But it is far otherwise when one asks, could this struggle have so reacted upon the structure of the animal as to thus modify its organs of reproduction? If no other obstacle presented, there would remain the seemingly insurmountable difficulty of accounting for the continuance of the species at all during the long interval required for the supposed adjustment of the organs. However that may be, we shall see that there is need for all the eggs laid and young hatched, and all the protective instincts and industries by which these ends are secured.

There is, of course, more or less irregularity in the operation of unfriendly agents, which are themselves subject to laws of variation. In such case there is a corresponding variation in the security of the species, and so of their increase. The effects of a season unfavorable to spiders or favorable to the growth of some enemy, or, on the contrary, advantageous

to the one and inimical to the other, may be seen in the number of araneads in that or the succeeding year. This is also true of the abundance or lack of a natural food supply. For example, the boat houses, fences, and outbuildings at Atlantic City fairly swarm with Epeiroids, especially Sclopetaria and Strix. This abundance is probably caused by the presence of greenhead flies with which the district is infested and which, affording an excess of food for the adult and partly grown spiders, relieves them from the necessity of preying upon their own species, which thus increase enormously as compared with sections a little distant.

But with these and such like exceptions, and notwithstanding all other variations, the distribution of a given orbweaving species in a given section will be found surprisingly uniform from year to year. The balance of hostile and unfriendly influences is held well poised by Nature's even hand. The enemies of spiders may be divided generally into those which assail the animal itself and those which affect its eggs.


FIG. 321. A moulting lizard eating a spider.

Season Changes.

Among the enemies of spiders, as of all other creatures, may be placed the changes of the seasons. The araneads' power to endure cold is great, but an unusually cold and moist winter will destroy many. Heavy rains prove fatal, especially to the young, and to females great with eggs—beating down the foliage in which they are ensconced, or sweeping the creatures themselves to the ground. The extreme tension of the abdominal sac under the distended ovaries makes fatal a shock that otherwise would work little harm.

Animals.

It is well known that toads and lizards take kindly to a spider diet. In southern Florida I once found a young lizard, while in the act of shedding its skin, and with the white moult still adhering to it, devouring a large Tetragnatha. (Fig. 321.) Many birds relish spiders and pursue them at all seasons, plucking the Sedentary species out of their very webs. In the autumn, when the broods of younglings are all afloat upon their little aërial ships, swallows and swifts, birds that take their prey upon the wing, have been seen skimming the tiny balloonists into their bills as they coursed the air. A specimen shot for examination showed the accuracy of the observation by the presence of spiderlings in the crop. It may be said in brief that all the larger animals with

insectivorous habits embrace the aranead nations also in their menu. Monkeys eat them; Hentz discovered a rat eating Oxyopes viridans;[1] and we have an account, which may pass for what it is worth, of even sheep upon the Steppes of Russia devouring certain ground spiders.[2]

Cannibalism.

Many spiders while yet immature fall victims to the voracity of their own species. I have elsewhere considered the charge of cannibalism as lodged against spiderlings while yet within the cocoon, showing that as a rule their cradle life and earliest babyhood are largely exempt from the perils of internecine hunger. But when once the solitary habit of the race has compelled the individuals to separate and dwell apart, Nature relaxes her restraining influence and hunger converts all available objects into legitimate prey. After this period it is not possible to defend our aranead friends against the charge of cannibalism, even of the most revolting kind. Brothers and sisters eat each other up without hesitation, and since, naturally, fellow broodlings are likely to pitch their tents and spin their snares in closest contiguity, it comes to pass that many of every brood are devoted as sacrifices to the growth and development of the few survivors to whom Nature has committed the perpetuity of the species. Outside of these limits, everywhere, spiders will prey upon their kind as opportunity allows, even the hours allotted to courtship and amatory embrace not being wholly exempt from the perils of this general tendency.

Fig. 322. A wasp plucking an Orbweaver from its snare.

II.

Perhaps the most persistent and destructive natural enemies of spiders are certain hymenopterous insects belonging to the large family of wasps known popularly as mud daubers and diggers.

It has often been remarked by ordinary observers that wasps can visit a spider's web not only with impunity, but as a successful assailant of the occupant thereof. This fact has crept into literature, and is embalmed by Goethe in a striking allusion to his father. "Willingly," he writes in his autobiography, "as I have made myself familiar with all sorts of

[1] Spiders of the U. S., page 46. [2] Walckenaer, Apt., Vol. I., page 172.

conditions, and many as had been my inducements to do so, an excessive aversion from all Inns had, nevertheless, been instilled into me by my father. This feeling had rooted itself firmly in him on his travels through Italy, France, and Germany. Although he seldom spoke in images, and only called them to his aid when he was very cheerful, yet he used often to repeat that he always fancied he saw a great cobweb spun across the gate of an Inn so ingeniously that the insects could indeed fly in, but that even the privileged wasp could not fly out again unplucked." But the number of those who, having observed the scathless incursions of "the privileged wasp" into cobweb domains, also know the purpose thereof, is exceedingly small. Yet it is inspired by one of the most common and interesting instincts in the insect world.

Goethe on Robber Wasps.

If we follow the wasp a little space backward from her cobweb raid, we shall see her fluttering over the muddy margin of pond, puddle, or stream. She is seeking mortar, which, gathered between her mandibles, she carries away through the air. Following her flight, we find her engaged upon the broken face of a cliff, the rugose surface of a wall, or the rough boards or beams in angle or cornice of some house, stable, or outbuilding. She carefully spreads her mortar, smooths it, rounds and arches it, until, after many successive visits to the mud bed, she has built a cell about an inch long and three-eighths to half an inch thick. (Fig. 323.) The middle of this cell is a hollow cylinder, within which the mother wasp, for such the little mason is, deposits a single egg. It is at this point that the raids upon spider webs begin. The egg in course of time is to become a ravenous, flesh eating worm, an arachnophagous larva; a soft, legless, whitish maggot, with a somewhat horny head and a strong pair of jaws, but no other weapons whatever. The food which Nature foreordains for it is living spiders, and those spiders the mother proceeds to capture and entomb within her mud daub nursery. On this errand she may be seen hawking over and near cobwebs of various sorts, venturing within the meshed and beaded snares that prove fatal to most incomers, and sometimes even to herself. She rarely fails in her errand. If the aranead occupant, expectant of prey, sallies forth to seize the intruder, it finds itself a captive, not a captor. For the wasp shakes the silken filaments from feet and wings, turns upon the spider, seizes and stings it, bears it to her cell, and thrusts it therein.

FIG. 323. The nidus of the mud dauber wasp.

She does not limit her hawking to cobwebs, but flutters over flowers, burrows among leaves, creeps with nervous, twitching tread along branches of trees, wherever spiders dwell or hunt, and with relentless cunning, zeal, and ferocity snatches those creatures away to add to the growing store

within her egg nest. At last the cavity is filled, the circular opening sealed up, and the spiders left literally entombed alive within that clay sarcophagus.

If one at this stage should break open the mud dauber's cell, he might dispute the statement that the imprisoned spiders are alive. To all appearances they are dead. In point of fact they are simply paralyzed. The effect of the poison injected by the wasp's sting within the tissues of her victim is such that all activity is at once and completely suspended, without destroying life. Thus, when the larval waspkin awakes to the pangs of hunger, it finds itself in the midst of a generous supply of the very food which Nature intended for it. The mother whom it is never to know, and who already perhaps has paid the last debt to Nature, had consumed her closing days in providing for the offspring which she was never to see. I have found these larvæ, fat, white grubs, in the midst of their "preserved meats," feasting thereon, and have wondered at their enormous appetite and the greedy vigor with which it was satisfied. (Fig. 324.)

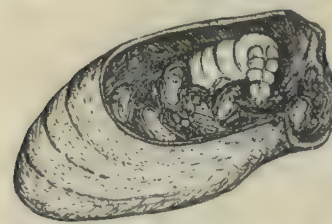


FIG. 324. A wasp larva feeding upon spiders.

Thus, before the era of man, Nature, in the person of a wasp, had solved the problem of preserving animal flesh without impairing its value as food. A like discovery by the human species, with due application to the edible domestic animals, would solve an important problem in commercial economy which has only been distantly approached by the ice chambers within which great transportation lines convey butchers' meats.

Wasps' Poison.

It would be interesting to know the nature of the poison which produces such remarkable effects, but one cannot hope that it will ever be procured in sufficient quantity to permit analysis. How long the virus may preserve its peculiar effect before death results, or whether a spider once stung can recover health, and to what extent sensation is retained, have been points of inquiry and of some experiment. On two occasions I kept under observation spiders rescued from the jaws of wasps. One specimen was a species of Tubeweaver, which I took from a blue wasp; it lived about two weeks. The other species was a large female Wolf spider, taken by a friend and sent to me October 5th, 1875. It lived until the 17th; twelve days. During this period the creature remained entirely motionless and the limbs retained any position in which they were placed. These examples indicate that there is no recovery from the poison, and that death is suspended for about two weeks.

I do not know the exact period required for the development of the wasp egg to a feeding larva, but it is something longer than two weeks. In some cases I have found the spiders within the wasp's nidus dead and

shriveled, the egg probably having proved infertile. Again, a few spiders would be dried up, while others were plump and edible, a condition in which more frequently most of them are found. It is certainly one of the unhappy possibilities in the destiny of the spider that it may be constrained to abide in a living death within this dark vault awaiting the awakening appetite of a voracious worm. It is to be hoped that a kindly Nature has so far tempered this hard doom as to deprive the entombed creature of all consciousness of her condition and consequent suffering therein. Indeed the evidence is well nigh conclusive that sensation is wholly suspended at the prick of the insect's sting.

III.

With the single exception, perhaps, of one small order, Neuroptera, no order of insects is exempt from the attacks of the all devouring wasps. Some provision their nests with grasshoppers, some with cockroaches, some with snoutbeetles of various kinds, some with ants and bees, a few with different kinds of bugs, frog spittle, insects, and plant lice; a great number of them with various kinds of two winged flies, and a still greater number, perhaps, with the larvæ of various moths.[1] Most observing country lads have noticed the assault of the handsome digger wasp, Sphecius speciosus Drury (Sphex), (Fig. 325), upon the so called "locust," the cicada or harvest fly, and I have dug that insect, Cicada pruinosa, out of a burrow of this wasp in the terrace of a West Philadelphia yard.


FIG. 325. The Cicada wasp (Sphecius speciosus.)

Those wasps which prey upon spiders comprise many distinct species belonging to widely separated genera. Some of these gather many spiders into one cell, others only one. The insects heretofore noticed are of the former class, the species most destructive in this region being probably the common indigo blue mud dauber, Chalybion cæruleum Linn. (Sphex). (Plate V., Fig. 7, natural size.) The larval cells of the blue mud dauber are commonly laid in small masses, one on top of another. (Fig. 323.) The cells of the common mud dauber are composed of one or more layers or tiers of clay tubes, arranged one above another or side by side like a set of Pan's pipes, and cemented to some surface protected from the weather. One such specimen, collected in the autumn (Fig. 326), I kept in my cabinet, and about the beginning of July following, a number of black digger wasps, Trypoxylon politum Say, escaped therefrom.

[1] Walsh, American Entomologist, Vol. I., No. 7, 1869, page 126.

I obtained no other species from these nests, but cannot affirm that no other escaped.[1] It may be a question, perhaps, whether the mud daubs were made by Chalybion or Trypoxylon; but we have the great authority of the late Benjamin D. Walsh that the latter species is really a guest wasp, not building and provisioning any nest for itself, but laying its eggs in the nest built and provisioned by the former, thus appropriating for its own future progeny the spider store laid up by the industrious Chalybion for its young.[2] It is curious and suggestive to trace this use and wont from the guest wasp and the cuckoo up to the human species as represented alike by the imperial "annexers" of Europe, Africa, and the Orient, and the "land grabbers" of the Indian Territory, the "squatter sovereigns" of the border, and the "claim jumpers" of Rocky Mountain mining districts.

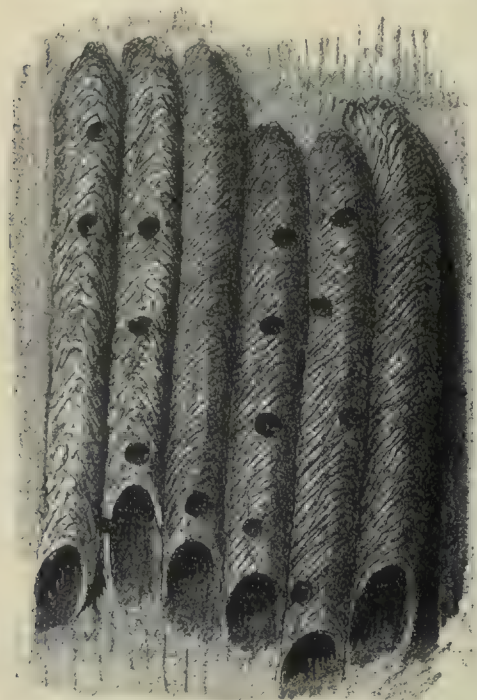


Fig. 326. Series of "Pipes of Pan" mud daub cells, from which escaped Trypoxylon politum.

Among the wasps that provision their nests with single spiders is the common blue digger wasp, Chlorion cæruleum Drury (Sphex), which, unlike species hitherto alluded to, burrows in the earth. It excavates its egg nest in an incredibly short time, sometimes consuming not more than a minute or a half minute, and then places therein a single egg together with a spider, which is generally a large one. With its front pair of feet it then scrapes back the dirt which it had withdrawn, frequently stopping to pat it down with its abdomen. When the hole is filled the surface is smoothed to the level of the surrounding soil. The large and beautiful Elis 4-notata Fabr. (Scolia), (Plate V., Fig. 3), invades the burrows of Lycosids, especially Lycosa tigrina, and the small Priocnemus pomilius Cresson has been taken while carrying a Laterigrade, a species of Xysticus, in its jaws.

Tarantula Killer.

Another example of wasps that store single spiders is the large and beautiful Pepsis formosa Say (Pompilus), an inhabitant of the Southwestern States of North America, where it is popularly known as the "tarantula killer." (Plate V., Fig. 2.) This name is given because of its habit of storing its burrow with that most

[1] The figure here given (Fig. 326) was drawn from a series sawed out of a shed at Bellwood, Pennsylvania.

[2] American Entomologist, Vol. I., page 133.

formidable of our spider fauna, Eurypelma hentzii. (Plate V., Fig. 1.) I have seen this insect in Texas hawking for its gigantic victim, which showed by its hurried and excited action full consciousness of its peril as it fled with eager and trembling speed before its pursuer. The late Professor Buckley, of Austin, describes an encounter on Texas soil between these two formidable creatures.

The tarantula killer is a bustling, unquiet insect, always in motion, flying now here, now there, and when running on the ground its wings are in a state of constant vibration. Should it discover a tarantula it begins instantly to fly in circles in the air around its victim. The spider, as if knowing its fate, trembles violently, standing up and making a show of fight, but the resistance is feeble and of no avail. The spider's foe soon discovers a favorable moment and darts upon the tarantula, whom it wounds with its sting, and again commences flying in circles. The injured spider is thrown into a tremor, and often becomes at once paralyzed, though the influence of a second, and even a third, wound is sometimes necessary. Sooner or later the spider becomes powerless when the victor approaches, carefully feeling its way to see if its work has been effectually done. It then begins to drag the tarantula into a hole which it has previously dug in the ground, wherein it is covered up after the deposition of an egg.[1] The courage and address thus shown in assault upon so formidable an animal, and the strength and perseverance required for its subsequent entombment, are of the highest order and surely evoke admiration, however much we may pity a foe doomed to so hard a fate as to be paralyzed, buried alive, and afterward devoured by a greedy grub.

In estimating the ravages wrought among spiders by the various tribes of wasps, it must be remembered that in the above and all like cases, the mother wasp, although depositing but one egg in each nidus, has a number of eggs, more or less, to dispose of. As she never ceases her work until every egg is duly deposited and its future offspring provided for, the vast destruction carried into the aranead hosts during the period of maternal activity may better be imagined than expressed.

IV.

Special Selection of Prey.

The thought had occurred to me while examining the contents of mud daubs, that certain species of spiders were preferred by the wasps as provision, and that possibly certain species of wasps affect certain spider species. In case of the true Diggers, who store but a single individual, there is no doubt a narrower range for selection, and even a specific choice, as with the Tarantula killer and the Fourspotted Elis. But not so with mud daubers. I have found every

[1] Proceedings Amer. Ento. Soc. (Philadelphia), Vol. I., page 138. See also an account by Dr. G. Lincecum, Amer. Entomologist, Vol. I., No. 6, page 111.

great group of our indigenous spider fauna represented in broken cells. The most numerous are Orbweavers, many species of which I have collected from mud daubs.

It is, however, true that in the gatherings of any individual wasp there is apt to be a preponderance of a single species of spider. Thus it would seem that a wasp starting out with Epeira strix, for example, is apt to devote herself chiefly to collecting that particular species. So with other species. Can it be that the mode of capturing her first victim, itself somewhat a matter of chance, so impresses itself upon the "brain" of the wasp that she almost mechanically drops into the same mode for subsequent capture, and thus finds herself habitually hunting along the trail of the domicile and hiding place uncovered in her first capture?

Next to Orbweavers, Laterigrades perhaps have been oftenest found by me in mud daubs. The species most frequently seen is the large yellow, white, or variegated species, Misumena vatia, which lurks for its prey on flowers, the mimicry of whose colors (see Chapter XII.) seems, in this case, not to be a "protective" resemblance. Here again, where this spider is found it usually predominates, as though the wasp, making her original capture upon the habitual feeding grounds of the species, had gained what might be called an "experience" and followed in the lines of her first finds.

I find some confirmation of my own impression in the opinion expressed by Mr. John Abbot, who observed the habits of American spiders in Georgia as early as 1792. He says that wasps generally confine their hawking to one species, when in search of spiders with which to store their mud daub nests.[1]

If we now turn from the more arboreal species to those which during the day will be found chiefly upon their webs, we shall observe a strong tendency in the same general line of habit. That vigorous and destructive Retitelarian, Theridium tepidariorum, so common in our outhouses, when found within a mud daub will be the prevailing species. Such Orbweavers as Argiope argyraspis, Tetragnatha extensa, Epeira labyrinthea, or Argyroepeira hortorum, which habitually hang upon their webs and must be thence seized by the raiding wasp, I have found subject to the same general tendency. It is needless further to multiply examples. I disclaim the purpose of indicating here an inflexible conclusion, or even one sustained by satisfactory evidence. But the facts which have fallen under my notice do justify one, if not in inferring, at least in suggesting, what future observers may find worthy of careful study. The line of inquiry certainly points along fields full of interest.

A brief reference to some of the special characteristics of a few of the spider species preyed upon by the mud dauber wasps will give a better

[1] Walckenaer, Hist. Nat. des Insectes, Aptères, Vol. I., page 174.

idea of the skill and acumen of these creatures in their raids. For example, there is no species with stronger secretive tendencies than Epeira strix. Its ordinary hiding place in a rolled leaf is so carefully selected and separated from its snare that I am continually thwarted in search for it. Yet the mud dauber finds it. So with the Laterigrade spider Misumena vatia. Its mimicry of the various colors of the particular flowers upon which it lurks, is surprisingly exact, although for the most part it affects yellow and pinkish white colors. Yet it is precisely this species which the wasp, in her industrious quest among leaves and blossoms, most frequently falls upon. I confess myself equally puzzled and interested at the facts which here present themselves. If one were at liberty to do so, he might fancy that this curious hymenopter feels some trace of that noble rage which inspires the breast of the huntsman, and, scorning more inglorious game, devotes herself to that which most excites her enterprise and evokes her skill. I have admired the intensity of action shown by the blue mud dauber when hunting spiders among bushes. It fairly jerks itself along from leaf to leaf and from stem to stem, prying under every corner and thrusting its antennæ beneath leaves, peeking into every cranny, angle, and nook where a spider could possibly be reposing. I do not wonder, after watching one of these creatures stalking its prey, that even the most secretive of our araneads fails to escape the detective skill and quenchless ardor of the remorseless insect.

Characteristics of Captives.

The solitary wasps, diggers, and mud daubers are not the only ones whom maternal instinct makes hostile to spiders. The social or paper making wasps may be included in the same list. The digger wasps appear to feed upon vegetable matter exclusively, although they provide animal food for their larvæ. It is difficult to account for the development of such a habit and such a taste. How could the insectivorous habit have come to a larva by heredity from a nectar feeding ancestry? On what principle can one explain why a mother with such a taste should provide for a sarcophagous offspring? Evolutionism has here a series of facts that lay formidable obstacles in its path.

Social Wasps.

If, now, we could show in the digger wasps some such facts as appear in the life of the social wasps, we might, perhaps, escape the difficulty. These insects also feed upon the honey and pollen of flowers, but the opportunity to acquire a taste for animal food is sufficient, for they directly feed their larvæ as do bees and ants, not leaving them to serve themselves as do the young of the mud daubers. That food consists chiefly of desiccated insects, but spiders contribute a portion to the larval bill of fare. The assaults of hornets upon the flies swarming in country kitchens are well known to American housewives; the webs of spiders are raided for the same purpose. These captives are chewed into juicy pulp and fed by mouth to the white worms that occupy the regular cells

of the beautiful paper nest. Now, in the act of reducing spider flesh to pulp it is natural to suppose that a taste for such food might be acquired (and, perhaps, it is even gratified) in sufficient strength to lay the foundation, at least, for an insectivorous habit in the progeny.

But our mud dauber does not feed her own larvæ at all; the far away originals of her species could have had no reasonable origin for a faintest suggestion of arachnophagous necessity in her progeny, and how then did she begin her persistent harvesting of spiders? It is, perhaps, possible to conceive that it may have come by the long, roundabout way of an insect chewing hornet or rust red wasp, but whether it is worth while to go so far to get so little, the advocates of the development theory must consider. The point in which the author is here specially interested is that the social wasps also are to be ranked with the enemies of spiders.

V.

Nest Parasitism.

It has been stated that all spiders are addicted to cannibalism, no species scrupling to prey upon individuals of its own order. As a rule, however, every species takes aranead prey, as it does insects, after its own characteristic modes. But the habit of cannibalism has a peculiar manifestation in the case of several species belonging to the Retitelariæ. One of these is a beautiful California spider, first sent to me by Mr. C. R. Orcutt, which is conspicuous by bright metallic silver markings upon a black triangular body. It is a small creature, but is evidently possessed of unusual cunning and ferocity. My knowledge of its habits is received from Mrs. Eigenmann, who forwarded to me living examples of both sexes. I have named the species (in litteris) Argyrodes piraticum.[1] The spiders were established on what seemed to be foundation lines of their own, which were attached to the broad foundation lines of a large orbweb of a species of Epeira. In one case an Argyrodes was found in the act of preying upon a large Orbweaver which she had encased within a silken enswathment and trussed up on its own web. It seemed remarkable to the observer that the little silvery spider could slay and eat a creature so much larger than itself, and, indeed, nothing short of actual observation would justify belief. My informant has found this pirate spider upon the snares of Gasteracantha, Argiope argenteola, and Zilla x-notata, as well as upon orbs of various species of Epeïra. It takes its station quite habitually upon the outskirts of the snares of these Orbweavers, from which point it makes its raid upon the lawful owner of the web, and perhaps, also, as Mrs. Eigenmann thinks, feeds upon the excess of insects which may often be found adhering in considerable numbers to the viscid portions of the orb.

The Pirate Spider.

[1] It has probably been described, but I cannot identify it.

This genus is represented by a species, Argyrodes trigonum,[1] common in the neighborhood of Philadelphia and throughout the Eastern States. It makes the usual nest of crossed and netted lines common to its tribe, but is also parasitic in its nesting habits, for I have found it on the retitelarian section of the Labyrinth spider's web, where it had made itself very much at home. I have also found it upon the webs of other species, as Linyphia communis and a small Theridium, and the upper intersecting supports and lines of Agalena nævia. Mr. Emerton[2] has observed the same tendency to nest parasitism, having found Trigonum in the upper part of the web of Linyphia scripta and also among the upper cross threads of Agalena nævia. There is no record, however, as far as I know, of this species actually preying upon its hosts, and the creature must be endowed with unusual cunning if it really succeeds in doing so.

Argyrodes trigonum.

The most decided example of this particular habit is found in a Line-weaving spider described by Professor Hentz as Mimetus interfector. Hentz found the species in Alabama; I have found it in Pennsylvania, Ohio, New York, and elsewhere; and Emerton has collected it in Massachusetts and Connecticut.[3] According to Mr. Simon the species also occurs in southern Europe.[4] Hentz says that Interfector spins a web resembling that of Theridium, but prefers prowling in the dark and taking possession of the snares of Epeira and Theridium after murdering the proprietor.

Mimetus interfector.

This singular depredator is not rare, and was usually found by its discoverer in houses, which enabled him to make many observations upon its manners. The first specimen observed was a female, which had made two cocoons under a table in his study, near and among the webs of several individuals of Theridium tepidariorum. The cocoon of Mimetus is oblong, and tapers equally at both ends, which are secured by many threads connected with a retitelarian web. The mother was watching the young, which were issuing from the lower one of her two cocoons. Thus she appears to possess in a strong degree that maternal solicitude which marks so many of her order.

A second observation discovered a very different state of feeling as to the young of other species, for she was observed devouring the eggs of Theridium tepidariorum, most probably after having eaten the mother. A third specimen was found dead in the web of some species of Theridium, which no doubt had killed it, an illustration of the fact that sometimes in her predatory expeditions she manages, like human robbers, to "catch a Tartar." A fourth Interfector was

A Spider Feud.

[1] Argyrodes argyrodes Wlck.

[2] Notes in Hentz's Spiders U. S., page 153.

[3] New England Spiders, Family Therididæ, page 17.

[4] Arachnides de France, Vol. V., page 29.

found eating the same Theridium that had devoured her predecessor. Such observations indicate a marked hostility existing between these two powerful examples of their family—a sort of aranead feud.

Professor Hentz sometimes enclosed specimens of these spider eaters with other araneads in a glass jar, in order to watch their motions. The moment another spider was thrown in, Interfector showed by its attitude that it was conscious of the presence of an enemy. For a moment it moved its first and second pairs of legs up and down, and then slowly approached its victim, and generally killed it. A Theridium tepidariorum thrown into the jar manifested great terror, but in a little while, or, as Professor Hentz puts it, "after some seeming reflections upon fortitude and necessity," it prepared for the mortal combat, and cautiously advanced towards the Mimetus, which began to move more slowly. Theridium, when near her adversary, threw out a long thread on which were several globules of transparent fluid. This partially succeeded, for Mimetus was caught by one leg, and while Theridium retreated for observation it was dragged about for a long time before it succeeded in freeing itself. The battle presently was renewed, and this time Theridium was conquered and eaten.[1]

Spider Duels.

From these interesting observations it appears that this formidable species of Theridium is a favorite object of attack with Mimetus. It is one of the most powerful and ferocious of its kind, being able to overcome and destroy the largest insects, and, as we have shown (Vol. I., Chapter XIII.), even to entrap and destroy a small snake and a half grown mouse. The courage, ferocity, and combative skill of the adversary which is able successfully to meet and vanquish it are thus at once manifest. I have found Mimetus interfector parasitic upon the snares of other spiders in the neighborhood of Philadelphia, but have never witnessed an actual attack by her. On one occasion I found her ensconced upon the snare of an Orbweaver, having evidently destroyed the occupant.

Mimetus syllepsicus, according to Hentz,[2] has the same piratical habit as her congener Interfector. This spider was found in the tent of Epeira labyrinthea, which it had no doubt killed. The webs and cocoons of its victim were untouched, and the squatter seemed perfectly at home in its new domicile. It strikes one as a remarkable development of instinct which has formed within a tribe and families having fixed sedentary habits a disposition to leave the snare and go, like the Wandering groups, to seek prey, and especially to raid the nests of fellow araneads therefor. But it may be noted that the piratical destroyer confines its raids to species whose nesting habits, in whole or in part, are similar to its own. That is to say, Mimetus finds its best preserves and hunting grounds upon the netted cross lines of Theridium and

Origin of the Habit.

[1] Spiders of the U. S., page 138. [2] Spid. U. S., page 140.

Agalena and the mazy annex of Labyrinthea, or the foundation lines of Orbweavers, which somewhat resemble her own retitelarian forms. The same remark applies to Argyrodes piraticum. It is found upon the compound snare of Zilla, which combines the orbweb with the retitelarian, and stations itself for its piratical raids upon the netted outlying and foundation lines of other Orbweavers. The same observation holds good as to Argyrodes trigonum, as far as its nesting parasitism is concerned, for she finds congenial raiding grounds within the netted lines that overhang the funneled sheet of Agalena and the orb of Labyrinthea. Undoubtedly she feels more courage, confidence, and vigor within an environment which gives her the sense of being upon her native snare.

It is possible for us to conceive that the habit may have originated from the facility thus presented for obtaining a foothold and home upon the webs of its neighbors. Having done this, it only needed a favoring opportunity, many of which must have presented, to throw the host of the web into the power of its guest. An act so advantageous would be likely to be repeated and persisted in; we have thus an easy way to the development of a fixed habit from what at first may have been an accidental feature in the life of ancestors. Even if this conjecture should be adjudged plausible, I cannot free myself from the wonder that so manifestly convenient a mode of securing food should have been fixed upon by so few of all the numerous species and innumerable individuals of the great Retitelarian tribe.

VI.

Body Parasites.

We pass now to note the parasitic enemies of Orbweavers and others of their order. Mr. Blackwall has shown that immature spiders, Epeiroids and others, are infested by the larvæ of Polysphincta carbonaria, a hymenopterous insect belonging to the Ichneumonidæ. This parasite is always attached to the upper part of the abdomen, near its union with the cephalothorax, and, although it proves a source of constant irritation, is secured by its position from every attempt of the spider to displace it. Being without feet, it appears to retain its hold upon its victim solely by the instrumentality of the mouth and a viscid secretion emitted from its caudal extremity. But one larva has ever been seen upon a single spider.

The ichneumon probably deposits its eggs on the spiders in the autumn, attaching one egg to each individual. In the spring, towards the end of May, having gone through its final moult and increased considerably in size, the larva becomes restless and rapidly destroys the spider, which it abandons after having reduced it to a mere corrugated skin. It then attaches itself to some convenient point, the cork of a bottle if it be in confinement, and begins to spin its cocoon, which it completes in a day or two. This cocoon is of yellowish white silk of compact texture, and

measures one-third of an inch in length and one-tenth in diameter. It is of an oblong quadrilateral figure tapering to its extremities, one of which is more pointed than the other. It is lashed to its site by numerous fine silken lines. In about one month the perfect insect appears. Blackwall found this parasite on four species of Epeira and two of Linyphia.[1] The same author figures Hermeteles fasciatus and H. formosus, ichneumon parasites on Agalena brunnea.[2]

An India Parasite.

A correspondent of "Science Gossip" gives an interesting note with drawings of an ichneumon wasp larva that preys upon a small spider in Ceylon, India. The spider usually attacked is a small black animal, with globose abdomen, that spins a loose irregular web on the under surface of leaves. The ichneumon wasp appears to oviposit upon female spiders only, the males being much smaller and unable to support the wasp grub. The egg is fixed to the abdomen of the spider close to its junction with the cephalothorax. The newly hatched larva immediately pierces the skin, and commences to absorb the juices of its host. The spider continues to feed, and remains apparently in good health until the parasite is full grown, when the latter destroys its victim, leaving nothing but the empty skin. The larva then commences to spin a flask shaped silken cocoon, attached generally to the under side of a cinchona leaf. It builds up the cocoon gradually, completing the walls as it proceeds, forming first a cup shaped receptacle, which is lengthened by regular additions to the open edge, and finally closed. A specimen under observation completed its work in forty-eight hours.[3]

FIG. 327. Parasitic larva on the body of an India spider.

It is an interesting fact, to which Blackwall has called attention,[4] that immature spiders infested by the larva of Polysphincta carbonaria do not change their skins. In what way the parasite can affect the animal thus to cause a suspension of so ordinary a function is not known, but the economy of the fact is apparent. If the moulting were to proceed, the parasitic larva would probably be cast off with the skin and would inevitably perish, thus causing a failure of its manifest end in Nature, which is to conserve the life of its kind both directly and indirectly—directly by feeding upon the body of the spider, and indirectly by checking the undue increase of that deadly enemy of insect tribes.

Spiders are also attacked by parasites within the body. A full grown specimen of Epeira cinerea,[5] sent me by Mrs. Treat, had been dropped into alcohol to kill it. Immediately there issued from the abdomen a white

[1] Ann. and Mag. Nat. Hist., Vol. XI., 1843, pages 1 and 2, and Spiders Gt. Br. & Ir., page 352.
[2] Spiders Gt. Br. & Ir., pl. xii., A A, B B.
[3] E. Ernest Green, Science Gossip, July, 1888, pages 159, 160.
[4] Ann. and Mag. Nat. Hist., Vol. XI., 1843, page 4.
[5] Epeira cavatica Keys.

ichneumonid larva one-half inch long. The spirit bath had evidently disturbed the creature when near the period of emerging, and being affected by it, it at once cut a way through the skin of its host, and wriggled out of the body into the alcohol, where, of course, it was destroyed. The site of this larva upon its host corresponded closely with that of the parasitic guest described by Blackwall, on the upper part of the abdomen. In size the two larvæ are nearly equal, and they probably belong to at least the same genus.

Parasites Within the Body.

Menge has added to our knowledge of the parasites infesting spiders, and I present a brief abstract of his observations.[1] Micriphantes, Theridium, Bolyphantes, and other species found crawling on the ground are infested with a cinnabar red species of Dermanyssa. But one of these is usually found on an individual, seldom two, and hardly ever three. It is fatal to the smaller varieties alone, and only infests the larger varieties while young. He found Mermis allicans on a Water spider (Argyroneta aquatica), and saw it escape from the body and tumble about in the water. During the latter part of June he took a female of Clubiona putris within its little silken sac on a stem of heath, and confined it for observation. A week thereafter it had disappeared, while within the sac, on a few horizontal threads suspended in the centre, lay a yellowish white pupa about five millimetres long, which had eaten the spider except the legs and a small part of the skin. In another week a winged insect, probably Henops marginatus or Oncodes pallipes, emerged from the pupa. During the brief adult life of this insect it takes no nourishment, but soon finds its mate and deposits its eggs upon the spider. Immediately after hatching, the maggot makes its way into its host's body, probably through the rima prudendi.

Menge on Parasites.

The same author describes two other parasitic larvæ which he failed to bring to maturity, but which probably also belong to the Hymenoptera. The first was found August 27th, upon the posterior part of a full grown female Arctosa cinerea, taken in the sand under fallen leaves; it was naked, reddish white, without feet, two millimetres long. It astonished the observer to note that the large spider remained perfectly quiet while the larva nibbled its way into the body, when a movement with the legs would have removed it. On the second day the spider was quite dead, and the larva was then four millimetres long. Eight days thereafter the larva had devoured the entire abdomen, the inner cephalothorax, and the thigh of one hind leg; it had increased about one-half in size, had satisfied its hunger, but was very uneasy. It was placed in sand to mature, and there overspun itself, but never further developed.

Parasitic Larvæ.

Another larva was found, July 28th, on an immature male of Miranda

[1] Menge, Preussische Spinnen, under Parasites of the Spider.

adianta, a species of Orbweaver. The parasite was two millimetres long, a yellowish green color, and smooth, except slight warts upon the back. At first the spider seemed to feel little inconvenience from its guest, but on the fourth day it sat motionless, and on the fifth it had been devoured, only a small bit of skin remaining, while the caterpillar lay curled up in a half circle, grown to twelve millimetres in length and two millimetres in width across the middle of the body. Subsequently it made a cocoon on the heath, but developed no further. None of the above larvæ moulted, which, according to Menge, is characteristic of parasites within the body, a habit that shows quite as striking adaptation as does freedom from moulting in an infested spider.

Gordius.

One of the most common superstitions heard among persons uninformed in natural history, is that a horse hair, when placed in the water under certain conditions, will turn into a snake. I have heard this fact averred by eye witnesses, who believed confidently that they had seen the hair suddenly come to life and wiggle off through the water. This astonishing statement is explained by that most interesting and least enjoyable of natural facts, parasitism. Crickets, grasshoppers, and spiders are known to be the hosts of a species of our common Gordius, the same probably as that described a number of years ago by Prof. Joseph Leidy as Gordius aquaticus.[1] From this eminent naturalist I have received a specimen of Lycosa scutulata, from which a Gordius was taken. I have figured the spider just as I received it, it being very much damaged when it came to my hand; the parasite is also drawn, both figures natural size. (Figs. 328 and 329.)

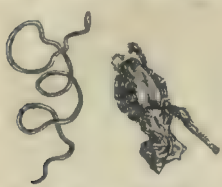


FIG. 328. FIG. 329.
Parasitic Gordius (FIG. 328) infesting Lycosa scutulata. (FIG. 329.)

VII.

Parasites on Eggs.

We have thus far considered the foes which assail the life of the spider after it has escaped from the cocoon. This does not complete the doleful record. Her cradle life is beset by even more formidable perils. The maternal instinct which, in the spider mother, prompts to cunning protection of her eggs in admirably wrought cocoons, inspires the Ichneumon fly to penetrate the silken bars and wards, and place the eggs of her parasitic young upon the spider's eggs. Our knowledge of the parasitic Hymenoptera preying upon cocoons of spiders has yet to be much enlarged, but we know that the genus Pezomachus is one of the most persistent guests, and that she carries vast ravages into the aranead ranks. A few notes will be given, culled from many observations upon the destructive habits of this genus.

[1] Proceed. Acad. Nat. Sci., 1850–51, page 98.

The outer case of a cocoon of Argiope cophinaria was taken at Atlantic City during winter (1883), and opened June 6th following. It was then pierced with several round holes. The lower part of the flask was occupied by a number of white cocoons of a parasitic hymenopterous insect. They were each three-eighths of an inch long, were grouped in a bowl shaped mass quite around the bottom of the egg sac, and were covered with a delicate white silken floss. Many of them were pierced at one end with a hole corresponding with the one on the outside of the spider's cocoon. (Fig. 330.) From these holes the insects, probably a species of Pezomachus, had made their escape, leaving their mahogany colored shells within their white pupa cases. Some of the Ichneumonid cocoons were without the single large opening, but had minute punctures not much larger than pin holes. These were doubtless the exit holes of a species of Chalcidian.[1]

Double Parasitism.

Thus the larvæ of the parasitic Ichneumons were themselves preyed upon by a parasite. However, in each case some individuals of the original host escaped the parasitic destroyer. The Chalcidians did not destroy all the Ichneumons, as the exit holes attested; and, notwithstanding the entire lower part of the spider's egg sac was occupied by the hymenopterous encampment, whose white tents pushed up against the brown wadding spun by the mother spider, a large number of young spiderlings occupied the field. They were active and apparently healthy, scrambling among the woolly fibres of their home quite down to the cocoons of their invaders. Whatever ravages the Ichneumons may have made among the spiderlings, there were certainly enough of them still left. I have found other cocoons of Cophinaria similarly occupied with some of the perfect Chalcids entangled in the spider silk.

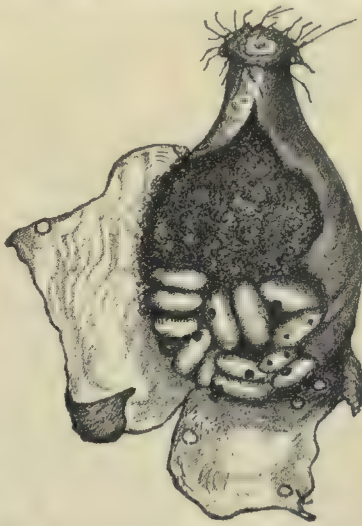


FIG. 330. Cocoon of Argiope cophinaria, opened to show the pupa cases of a brood of parasitic Ichneumon flies.

These are not the only examples of peaceful occupation of a cocoon by the Orbweaver's young along with various "squatter sovereigns" of the parasitic tribes. I received from Mrs. Eigenmann, San Francisco (August, 1883), a specimen of Epeïra accompanied by what was supposed to be, and probably is, the cocoon. The adult spider, a female, is black, with faint dorsal foliated marks, and the young are beautifully marked with black and white. A large number

Treble Parasitism.

[1] Prof. Wilder has observed the same fact. Proceedings American Association Adv. Science, 1873, page 258.

of these were alive within the cocoon, a flossy ball of blackish colored silk different from any I have ever seen. In the centre was a small agglutinated mass of white parasitic cells, similar to those above described, to which a number of infertile spider eggs still clung. These cells were probably those of an Ichneumon, Pezomachus dimidiatus Cresson (Plate V., Fig. 5, female, × 4), an example of which was found, dead, clinging to the padding of the spider's egg sac. They had evidently burrowed within the mass of Epeiroid eggs, destroying a number but leaving still many to hatch out. Within these parasitic cocoons, which were all empty of their original occupants, were several Dermestid larvæ of various sizes. They were in an intense state of activity, but I did not observe that they preyed upon the living spiders. Besides these I found in the box two specimens of a minute Chalcidian, and several living specimens of a small species of ant, apparently an undescribed Solenopsis. Thus this family consisted of the original spider hosts, their proper parasitic guests Pezomachus, the parasite's parasite Chalcidian, the universal destroyer the Dermestid larvæ, and that inquisitive interloper the ant. It has not been my fortune to see a more miscellaneous natural combination than this.

FIG. 331.

FIG. 332.

FIG. 331. Cocoons of Pezomachus gracilis in a Laterigrade spider's cocoon. FIG. 332. Spider cocoons; one healthy, one infested.

Pezomachus gracilis.

Pezomachus does not limit herself to any single group of spiders, but apparently preys upon all. I succeeded in hatching several, both male and female, of Pezomachus gracilis Cresson (Plate V., Fig. 6, female, × 4) from cocoons of a Laterigrade spider. Two cocoons found on the banks of the Schuylkill, attached to the inner side of the bark of a tree, were joined together as at Fig. 332. One of these was completely occupied by Ichneumon cocoons. The spider's cocoons are made of very stiff silk, and are covered more or less thickly with minute daubs of mud. Through this covering Pezomachus had penetrated and lodged her eggs upon the spider eggs within. In due time they were hatched, devoured the eggs, the shells of which were within. Five pupa cases of the parasite occupied the interior. (Fig. 331.) In the adjoining cocoon were healthy young spiderlings and a few eggs.

English Parasites.

The cocoon of Epeira apoclisa of England is spun of yellowish silk, of a loose texture, about half an inch in diameter, and contains about two hundred and twenty spherical eggs. From this cocoon, on the 18th of July, Blackwall took both sexes of a small Ichneumon fly, the female of which is apterous, and on another occasion he obtained specimens of the same insect from the cocoon of Epeira umbratica.[1]

[1] Spiders Gt. Br. & Ir., page 327.

October, 1884, Mr. F. M. Webster sent me from Oxford, Indiana, a parasitized cocoon, evidently of some Saltigrade species, which appeared to be that of Phidippus morsitans. The cocoon contained within the outer flossy case about eighty cells or pupa cases and a number of mature black hymenopterous insects about one-eighth inch long. (Fig. 334.) The cells were ovoid, gray, blackish at the closed end, probably from excretions from the enclosed larvæ. One end was cut open, showing where the insects had escaped. (Fig. 333.) With the exception of a few hard, dry, yellowish brown examples, all the eggs of the spiders had disappeared.


FIG. 333.

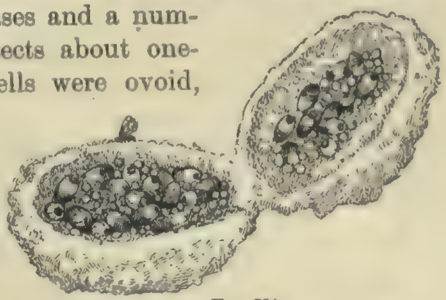


FIG. 334.

FIG. 333. Magnified cell of parasitic hymenopter, probably Acoloides saïtidis. FIG. 334. Saltigrade cocoon, with parasitic cells enclosed, somewhat magnified. The fly on the edge is about natural size.

The specimens were sent to Mr. L. O. Howard,[1] who thought them to be Proctotrupids, belonging to the subfamily Scelioninæ, and seeming to form an entirely new genus.[2]

Saltigrade Guests.

This gentleman has lately published [3] a description of a hymenopterous parasite on spiders sent to him by Mr. L. Bruner, of Lincoln, Nebraska, which was collected from the eggs of a Saltigrade, Saitis pulex. The eggs of this spider are a little more than a millimetre in circumference, and each egg harbors but one parasite, which issues by splitting the egg case open, rather than by gnawing a hole. This insect belongs to the same family and subfamily and is probably the same species as that collected by Mr. Webster. Mr. Howard has named it Acoloides saïtidis, and a copy of the drawing of the insect is given at Fig. 335. In the same connection Mr. Howard describes, under the name of Bæus americanus, a new species, a minute wingless Scelioninæ, from specimens sent him ten years ago by Dr. Marx, who appears to have received them from Col. Nicholas Pike, of Brooklyn, New York. They are labeled: "Parasites in spider's eggs in an orange cocoon." Dr. Marx, after examining the eggs, expressed the opinion that the host from which these little parasites were established


FIG. 335.

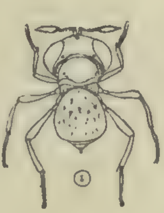


FIG. 336.

FIG. 335. Acoloides saïtidis, a hymenopterous parasite on the Saltigrade, Saitis pulex. FIG. 336. Bæus americanus. (After Howard.) Natural sizes shown in the circles.

[1] Bureau of Entomology, Department of Agriculture, Washington, D. C.
[2] Proceed. Acad. Nat. Sci., Philadelphia, 1884, page 294.
[3] "Insect Life," Vol. II., No. 9, 1890, page 269.

belonged to the Orbweavers. (See Fig. 336.) The natural size of the insect is given within the circle at the side of the drawing. The insect may not have been directly parasitic on the spider's eggs, but on the larvæ of Pezomachus or some other spider parasite.

The above examples are sufficiently representative, and they indicate the mode in which the Hymenoptera wage war upon the Araneæ. As to the extent of that war I may simply say that I find a large proportion of Epeïroid cocoons infested by parasites. In going among the old cocoons in the spring it is often more usual to find them occupied by cocoons of Pezomachus than full of healthy eggs. Of five large egg nests of Epeira cinerea now before me, not one is free from parasitic cocoons. Often the spider brood will be in part preserved; frequently the parasites have full possession; and, again, the traces of a full and healthy brood are shown by the shells or first moults within the central bag. Of course the ratio of destruction varies at different times and places.

Extent of Parasitism.

Fig. 337. Parasitized cocoon of Epeira cinerea, opened to show the infesting ichneumon cocoons.

There appears to be no special proclivity on the part of parasitic hymenopters to confine their operations to any species of spider. They appear to choose their host indiscriminately from among the cocoons in which the eggs are swathed. Pezomachus gracilis will attack the hard, stiff, and compact cocoon case of Argiope cophinaria, or will choose as a host the eggs of a species of Epeira, or indeed of other tribes.

This point needs further investigation, and would be a matter of some importance to solve with absolute certainty. It would greatly add to our respect for the discriminating powers of these strange insects if we were to establish the fact that they can select a spider's eggs even when they are hidden away under protecting cases so widely differing in appearance, construction, and location. The question would then rise, in what manner do the ichneumons determine the presence of the eggs? Do they watch the spiders themselves? Are they able to detect the presence of spiders' eggs through the enclosing enswathment by some sense so delicate that it cannot be appreciated by human beings? The wingless condition of the females doubtless greatly favors them in their search for objects hidden away as spider's cocoons commonly are.

Parasite Preferences.

VIII.

These are not all the hostile agents arrayed against the embryo life of spiders. Parasitic plants as well as parasitic insects assail them, for not

unfrequently the eggs are destroyed by vegetable mold. According to the observations of Homburg, house spiders in the kingdom of Naples are subject to a malady which makes them appear hideous. Their body becomes covered over with scales, bristling one above the other, among which numbers of a species of mites are discovered. When the spider walks, it shakes itself and throws off part of the scales and some of the parasites.[1]

Mold, Flies, Birds.

One day I was dissecting a cocoon of Epeira sclopetaria, and had just turned back the white sheeting of the interior sac, thus quite exposing the eggs, when a house fly lit upon the mass, and instantly thrust her proboscis into and sucked out the contents of an egg. I permitted the insect to continue its feast long enough to show that the innumerable company of common flies only require an opportunity to wholly cut off and exterminate their hereditary foes at the very fountain head of life. Spiders themselves enjoy a meal of spiders' eggs; for example, Staveley speaks of two species of Clubiona feeding upon the eggs of other species.[2]

Birds have already been alluded to, in the chapter on Aeronautic Habits, as utilizing spider cocoonery in the construction of their nests. Among those addicted to this habit are the pewit,[3] the wren,[4] and the vireo. I have several specimens of nests made by a species of the last named bird, probably Vireo noveborocensis, collected in Fairmount Park, in all of which cobwebs have been used more or less freely. (Fig. 339.) I am told that this is habitual with that bird. The texture of the spinningwork shows, evidently, that it had been plucked from cocoons; and if this were done before abandonment by the brood, at least before hatching, the destruction of the contents must have followed. It illustrates the catholicity of habit among the animal races, that Dr. David Livingstone, the distinguished missionary explorer, found a like habit in Africa among the sunbirds.[5]

Bird Enemies.

FIG. 338. A cocoon nest of Epeira, rifled of its eggs.

Mr. Carl Voelker has a specimen of the nest of a hummingbird, which is composed in considerable part of various portions of spinningwork taken from the snares and cocoons of spiders. He has seen our common red throat hummingbird, Trojilus rubicolis, darting at the webs of spiders and gathering the threads in its bill for nesting purposes. He has also found minute spiders in the throats of birds of this species, and believes, therefore, that it is their habit to feed upon spiders. The Blue Gray Gnatcatchers also use spider webs for the construction of their nests, and thus probably destroy the young in their cocoons.

[1] Cuvier, Animal Kingdom, Ed. Lond., Vol. XIII., Supplement, page 463.

[2] British Spiders, page 101.

[3] Mr. Thomas Meehan, the botanist, is my authority for this statement.

[4] Mrs. Treat, "My Garden Pets." [5] Livingstone's Last Journals, page 453.

The above facts, uncovering as they do so hard a destiny impending over every stage of aranead life, might well awake sympathy in the breast of the most pronounced spider hater. To those who know the usefulness to man of the much enduring race, and view its destruction from the standpoint of human disadvantage, the facts are melancholy enough. But after all there seems a judicial fitness in the order of things which appoints avengers from the midst of the insect world against the chief destroyer of the insect hosts. Seeing, therefore, that some check is required upon the excessive increase of spiders, we may regard their relation to the Hymenoptera with some complacency from the view point of natural justice.

FIG. 339. Nest of Vireo noveborocensis woven together, with bands and threads of plundered spider webs.

IX.

Foolishly Hostile Man.

In speaking of the enemies of the spider we have thus far omitted one of the most determined and destructive—man himself. But it will be observed that I have been writing of the natural enemies of spiders, and in my opinion man cannot reasonably be classed among these. His hostility to the various families of the spider world is without reason not only, but is against reason. It is an example of indulgence in a prejudice which has been long fostered by

ignorance, and which, I am thankful to record, is yielding before the light of modern science. In truth, the spider is not only a harmless creature as far as man is concerned, but is, on the contrary, a most helpful one to him in many respects. She is one of those checks established in the economy of Nature against the increase of insects whose presence would make the world well nigh uninhabitable by the human species.

Some idea of the destruction wrought in the insect world by the cunningly devised snares of Orbweavers may be had from the following facts: I have counted nearly two hundred and fifty insects, small and great, hanging entangled in one web. In another net, in Fairmount Park, I counted thirty-eight mosquitoes; in another, hung under a bridge at Asbury Park, and out of reach, there must have been two or three times as many. Greenhead flies by the legion have been seen in the snares that fairly enlace the boat houses at Atlantic City and Cape May. Very small spiders prey upon microscopic insects, like gnats, and devour myriads. A glance at the fields, bushes, and trees on a dewy morning in September will reveal an innumerable multitude of webs spread over the landscape, all occupied by spiders of various ages, sizes, and families, and all busy destroying the insect pests of man. These webmaking spiders thus revealed are only a part of the numberless hosts engaged in this friendly service. On the ground, in crevices and crannies into which man never looks; lurking on flowers, on leaves, on limbs and twigs of trees, shrubs, grasses; in barns, cellars, outhouses; everywhere, indeed, upon the face of Nature, one who will take the pains to look will find legions of spiders carrying forward day and night without cessation the same vigilant and unrelenting warfare upon the insect world. They are of all sizes and of various forms; in all stages of their life, from the spiderling upon its tyro web to the grizzly veteran just ready to give up its life as the frosts of autumn fall. If one stops to consider that all these creatures must find food, and do find food, and that the chief supply is furnished from the realms of insect life, he may form some faint conception of the destruction which is wrought, and, by consequence, the service done to man.

Arachne as a Forest Keeper.

To the testimony thus gleaned from field observations we may add the evidence of postmortem examination made by a careful and learned student with the aid of the microscopé. Dr. C. Keller, of Zurich, claims that spiders perform an important part in the preservation of forests, by defending the trees against the depredations of aphides and insects. He has examined a great many spiders, both in their viscera and by feeding them in captivity, and has found them to be voracious destroyers of these pests; and he believes that the spiders in a particular forest do more effective work of this kind than all the insect eating birds that inhabit it. He has verified his views by observations on coniferous trees, a few broad leaved trees, and apple trees. An important feature of the spiders' operations is that they prefer shaded

spots, and therefore work most in the places which vermin most infest, but which are likely to be passed by other destroying agents.

We thus see that man is not only indebted to Arachne for protection to his own personal safety and comfort, but also for the protection of his forests, fruit orchards, gardens, and fields. Indeed, the whole vegetable world may well join with man in a tribute of gratitude to a creature whose service is so eminently useful.

Arachne a Philanthropist.

Surely, in view of these facts, we need not hesitate, through fear of being charged with undue enthusiasm, to declare the spider a universal philanthropist. She labors unceasingly to check the increase of a horde of tiny insect enemies which else would banish the human species from many parts of the earth. Nor does she make reprisals of any sort for all this service. She never attacks fields, harvests, vineyards, and orchards, like beetles, grasshoppers, and various other insects in the perfect and larval state; she never forages upon the goodies in ladies' kitchens and pantries, as do roaches and ants; she does not torment and afflict by cutting, piercing, sawing, and pumping, by buzzing, humming, and blowing, like the mosquito and house fly, to say nothing of less desirable denizens of the entomological kingdom. An occasional (and doubtful) "spider bite" one does hear of at rare intervals; a harmless cobweb here and there in a cranny or corner of one's house, that is all that can be charged against her. Yet this useful aranead is despised, abhorred, persecuted, and slain with a zest that is hardly shown against any other creature, except the snake. No; man is not a "natural" enemy of the spider, but an enemy by a culture most unnatural and unreasonable. What stupid ingrates men are often found! "What fools these mortals be!"

X.

Influence of Enemies on Industry.

This subject could not be held complete without reference to the relation which undoubtedly exists between the facts which the chapter uncovers and many of those interesting habits described in this volume and elsewhere. That the instincts and industry of spiders are in a large degree protective will not admit of dispute. It is certainly a reasonable theory that they have in part, at least, arisen or been modified by that fact. That is to say, the original endowments of the creature have been enlarged and varied by the peculiar perils with which successive generations have had to contend.

We have already anticipated the influence of enemies in developing the industrial habits of spiders, in the chapter on Nesting Habits and Protective Architecture. (Vol. I., Chapter XVII., pages 307–309.) By referring to the summary of the various forms of tents there described, the importance of this influence, particularly in the case of Orbweavers, will be noted. It appears that Orbweavers live continually in dread of enemies, and that

their whole life is spent in a defensive industrial warfare for the protection of their persons. In order to illustrate this truth a little more fully I propose to consider the habits of those spiders which make burrows in the ground, namely, the Citigrades and Tunnelweavers. Both of these tribes, but particularly the latter, are noted for the admirable dwelling places which they construct. I hope to show that these ingenious homes are largely defensive.

1. Moulting Tents. Beginning with the Citigrades, we find, in the first place, that during the period of moulting, when the spider is conscious of its defenseless condition by reason of physical weakness, it is in the habit of protecting itself by covering the mouth of its den with a silken sheet, or by spinning a special cell in which to shed its skin.

2. Cocooning Caves. Again, I have observed Lycosa, when about to make her cocoon, construct a cell in the earth and carefully cover the entrance thereto with a silken curtain. She was animated, as I conjectured, by the wish to preserve herself from enemies during this crisis period of her life. I have also shown that it is the universal habit of these Lycosids to construct cocooning caves or nests underneath stones, logs, and like situations, which are carefully plastered and enclosed on all sides, leaving an entrance which is usually well protected from assaults of ordinary enemies. This appears to be a cosmopolitan habit; at least, Mr. Campbell tells us that some English Lycosids dig an irregular oval cavity about one inch by a half inch in diameter, close it with a conglomerate of silken threads and earth, and remain therein with the cocoon. He kept one Lycosid in confinement and twice destroyed her retreat, only to find another made the following morning. The top was covered with granular pieces of soil, such as might have been raked over the silken lining with her feet. In both the above conditions, namely, while moulting and while cocooning, these Citigrades appear to be driven to special industrial provisions by the impulse of self protection.

3. Climate Covers. That the same habit prevails as a protection against the destructive influences of climate is well attested. Lycosids everywhere appear to seal up the openings to their cylindrical burrows at the advent of winter. The advantage of such artificial closure, as a protection against winter cold, was well demonstrated by Mrs. Treat. A large example of Lycosa carolinensis, which makes a beautiful nest (Fig. 291, Vol. I., page 316) was brought from New Hampshire and domiciled in Mrs. Treat's ground. Its burrow was only eight inches deep, yet there was a marked increase of temperature above that at the surface. This could be discerned by placing the hand at the mouth of the tube. One cold morning when the thermometer stood twenty degrees above zero (Fahrenheit) a thermometer was introduced. It ran up to forty degrees, making a difference of twenty degrees in temperature between that prevailing at the surface and that within the burrow. Soon

after this test was made, late in November, the spider closed its burrow with a canopy of thick web, over which were drawn a few sticks and straws. It cannot be doubted that the advantage thus secured by the burrowing habit, against the exigencies of a severe winter, strongly tend to protect the life of Lycosids.

I have also called attention to the fact, while treating upon the cocooning industry and maternal instincts of spiders, that the industrial product of such skillful architects as certain Lycosids and the Trapdoor spiders, is probably influenced by the mother's wish to protect her eggs. I refer the reader to what is said Chapter III., page 64, merely remarking that it would indeed be strange were not the strongest feelings in animal nature to leave their impress in some form upon the industrial life of animals. I have also suggested that even the sexual excitement of the male reacts upon his industrial energies and tends to the development of a higher skill, at least in certain species. (See page 65.)

I now proceed to show that the necessity of self protection against their most persistent and formidable enemies, the wasps, has led certain Lycosids to adopt a special and interesting form of protective architecture.

4. Self Protective Industry.

We fortunately have abundant facts in the case of Lycosa tigrina,[1] as carefully observed and recorded by Mrs. Mary Treat.[2] Tigrina's method of working, as observed from a large female specimen in confinement, is as follows: She first spins a canopy of web over her tunnel, leaving a place of exit on one side. She next goes out and carefully moves over the canopy as if to see whether it is strong and secure. Satisfied that it is all right, she steps down, just letting her fore feet touch the web, while with her hind legs she feels and apparently examines the material. Finally, she selects a dry oak leaf about two inches broad and three in length, lays it over the canopy, and proceeds to fasten it down all around except at the entrance. After the leaf is made secure she reaches up and pulls down blades of grass, lays them over the leaf and dexterously fastens them down with webs. This makes a strong roof for her domicile. Then she goes within and puts the finishing touches on the inside. This done, she stands in the door of her neat apartment awaiting insects that may chance to come within her range. If a beetle, for example, approaches, she rushes upon it and bears it into her den. A few days after the work is thus begun, Tigrina completely closes the entrance to her domicile, and the observer avers that if she had not known the spot in which it was located, she would not have been able to find it.

Tigrina's Mossy Dome.

[1] Tarentula tigrina McCook, Proceedings Amer. Entom. Soc. (Section), page xi., May, 1879. The burrowing habit of this species is there for the first time fully described by me, and a brief description given of the female. Emerton (New England Spiders of the Family Lycosidæ, 1885) describes the species as Lycosa vulpina. I judge that my own name has precedence.

[2] Home Studies in Nature, Harper's Magazine, 1880, page 710.

At one time twenty-eight of these spiders were kept under observation in the observer's grounds. She visited them all frequently and found that more than half the number, both males and females, had closed their doors firmly. Some of the burrows were situated in bits of moss, and the moss was so cunningly arranged over them that the most expert naturalist would have found it difficult to tell where they were located. Mrs. Treat had often tested the matter with her friends, to see if they could find one of these concealed burrows, limiting their search to a few square inches of space. But they rarely hit upon the right spot. Mrs. Treat kindly contributed some of the coverings of these Tigrina burrows to my collection

Fig. 340. A vestibule and dome of vegetable débris reared over the burrow of Lycosa tigrina. Natural size. (From a cabinet specimen.)

of aranead architecture. They are masses of vegetable débris, moss, grass blades, chippage, dry twigs, the shell of an acorn, etc., arranged in an irregular dome several inches in diameter across the base and an inch or more in height. (See Fig. 340 and Figs. 341, 342.)

The Explanation. What is the explanation of this care shown by Tigrina in the covering of its den in midsummer? The closure in winter is explained by the natural desire to protect the burrow from frost and snow. The closure during or previous to the moulting season is explained by the fact that the spider requires especial protection at a period

of special weakness and inability for defense. The closure of the domicile just before cocooning is explained by the maternal instinct which drives mothers into hiding at that crisis period of life. But August is the time when insects are most plentiful in our climate, and one would think that then Tigrina would keep her burrow open in order more freely to prey upon insects.

The explanation is certainly found in the presence of a species of Digger wasp, Elis 4-notata Fabr. (Scolia). (Plate V., Fig. 3.) She belongs to the arachnophagous species, and, although the mother appears to feed upon nectar and honey, the grub feeds upon the juices of spiders, and the particular species affected by the wasp larva is Lycosa tigrina. The wasp is large and strong, has smoky brown wings with a strong purplish blue iridescence, and two bright orange spots on either side of the abdomen. She runs over the ground swiftly, peering here and there into various recesses, until she alights upon an open burrow of Tigrina. Down into this she plunges, and soon returns dragging up the inhabitant, which she has already paralyzed with her powerful sting. Woe now to all spiders with unclosed doors, for Elis is sure to find them!

Elis the Invader.

Sometimes two wasps are hunting in the same vicinity, and when one finds a spider the other tries to wrest it from her. A furious battle ensues. The combatants drop the prey and clinch in conflict, seemingly trying to stab each other with their stings. The victorious party returns to the spider, which is often heavier than herself, and proceeds to drag it to her nest. She moves backward for a time, drawing it over the ground, then tries flying a short distance, but the burden is so heavy that she soon comes to the ground again. She is so active and quick in her movements that one has to walk quite fast to keep abreast with her. She carries the spider several rods from where she obtained it, lays it down on the gravel walk, and hunts over the ground. Presently she finds a burrow which she had previously dug, takes up her spider, and disappears within. She comes out empty handed and proceeds to fill up the hole with the earth she had thrown up. She works so rapidly that one can scarcely tell which feet she uses most. She seems to dig with her fore feet and rake the earth in backward with her hind feet. Soon the hole is full. And now she makes a battering ram of herself by rapidly striking her body on the ground, as if to pound the earth down. This done, she rakes the ground all over and around the place to make it level, then collects small pebbles in her mandibles and lays them over the spot, until it looks little different from the surrounding ground. Elis also knows how to practice local mimicry!

The Burial.

When one of these mother wasps had retired, the observer dug up the paralyzed spider, which was about four inches below the surface, and found an egg sticking in the body. This egg hatches into a white grub

in about six weeks, when it at once begins to feed upon the stored spider. When full grown it passes into a chrysalis state, in which it remains until the following summer, when it emerges, a mature insect, and, like its mother, begins a remorseless raid upon the Tiger spiders. The wasps continue their raids for two or three weeks, only the spiders with closed doors escaping. Sometimes a spider will keep herself shut up for two weeks and then timidly open her door and look out.

After the end of August the maternal rage had exhausted itself, the wasps disappeared, and then Mrs. Treat found that out of twenty-eight spiders only five were left! These survivors soon opened their doors, and occasionally one would cut the threads of the spinningwork which unites the thatching material in such a manner as to make a sort of trapdoor, leaving hinge on one side. (See Figs. 341 and 342.) But more commonly a hole was left in one end of the oven shaped cover, which the spider would readily close by drawing the material together and fastening it with threads.

Danger Influences Industry.

It seems impossible, in view of such a careful and intelligent record as this, to doubt the fact that the instinct by which Lycosa tigrina is impelled to construct the vestibule roof and door to her den, has been vitalized by, or at least associated with, the natural instinct of self protection against the raids of its formidable enemy, the Digger wasp. This is further emphasized by the fact that the partly grown Tigrinas, who are not molested by the wasps, have never been observed to conceal their burrows in the manner of the adult. Tigrina's rude architecture is a product of her peril.

The defensive motive in the architecture of Lycosa tigrina, which is thus clearly demonstrated, serves as a key to the purpose underlying all the architecture, not only of the Lycosidæ, but of other burrowing species. The watch tower which guards the nest of the Turret spider (Volume I., Fig. 289, page 314); the interesting structure so closely resembling a bird's nest, reared above her nest by Lycosa carolinensis (Volume I., Fig. 291); and other forms of industry of which these are types, may all be considered as in part, at least, the result of protective industry.

Lycosa tarentula.

According to the account of Dufour, the habits of Lycosa tigrina and Lycosa arenicola are quite similar to those of the famous Lycosa tarentula of Italy, the heroine of the "Tarentula dance." This aranead forms a cylindrical burrow in the earth, often more than a foot long, and about one inch in diameter. At about four or five inches below the surface the perpendicular tube is bent horizontally, and it is at this angle that Tarentula watches for the approach of enemies or prey. The external office of the burrow is ordinarily surmounted by a separately constructed tube. This tube and outer piece of architecture rises about an inch above the surface of the ground, and is sometimes as much as two inches in diameter, being thus even larger than the burrow

FIG. 341 (upper figure). Vestibule of Tigrina's burrow, with door open. FIG. 342 (lower figure). The same, with door closed. Natural size. (Drawn from cabinet specimens.)

itself. The tube is composed of fragments of white silk fastened together with particles of clay, etc., and so artistically disposed, one above the other, that they form a scaffold, having the form of an upright column, of which the interior is a hollow cylinder. The tube is lined with silk throughout its whole length.[1]

XI.

Trapdoor Spiders.

I have no hesitation in also applying the key thus furnished by the habits of Tigrina to interpret the motive of Trapdoor spiders in their remarkable industry. With this in mind, and aided by other facts and conclusions drawn from a direct study of this form of nest, we may venture to approach the subject.

M. Eugene Simon has contributed largely to our knowledge of Tunnel-weaving spiders in a recent paper presented in the Annals of the Entomological Society of France[2] and in the Acts of the Linnean Society of Bordeaux.[3] His descriptions are accompanied by notes upon the habits and architecture of the spiders, with admirable illustrations, which greatly enlarge our knowledge of the nesting habits of these interesting creatures, who rank among the most skillful artificers of the animal world. Mr. Simon's notes were made from specimens obtained in Venezuela and North Africa, the Venezuelan specimens being studied personally during a visit to that country. A comparative study of his papers enables us to trace the progressive development of the nesting architecture of Tunnelweavers from the simplest tube in the ground to the hinged doors or trapdoors which close the silk lined burrows, and which are so well known for their mechanical perfection.

1. Tarantulas' Straight Burrow.

The simplest form of burrow is that of the Tarantulas, which represent the largest known spiders. These huge araneads appear to depend wholly upon their size to resist the assaults of enemies who invade their den. At least I have not found satisfactory evidence that they erect any artificial barrier over the entrance to their tunnels.

A more complicated burrow and one better serving for defense is that of Leptopelma cavicula of northern Africa. The drawing (Fig. 343) shows a section view of the upper part of the burrow, the entrance to which is without any door or other defense as in the case of the tarantulas. The burrow descends perpendicularly for a little ways, but at the top a special branch diverges laterally, which curves and again descends perpendicularly for a considerable distance. At the summit of this second and parallel perpendicular tube another branch issues, inclining upwards towards the surface. A glance at this structure, if we suppose it to be

[1] Lucas, Hist. Nat. des Animaux Crust. et Arach., page 357.

[2] Extrait des Annales de la Société Entomologique de France, "Arachnides du Venezuela," December, 1887, April, 1888, pages 170–220, plates i., ii., iii.

[3] Actes de la Société Linnéenne de Bordeaux, Vol. XLII., 1888.

FIG. 344.

FIG. 346.

FIG. 343.

FIG. 345.

FIG. 343. Burrow of Leptopelma cavicula; section view of upper part. FIG. 344. Lily shaped tube of Leptopelma elongata. FIG. 345. Turret of Dolichoscaptus inops. (Natural size.) FIG. 346. Turret, with trapdoor, of Dolichoscaptus latastei, supported on a plant. Four inches high. (After Simon.)

characteristic of the species and not an accidental formation, will show that it makes an admirable protection against heavy rains, which sink away into the first burrow as a kind of reservoir, enabling the spider to escape by the diverging branch. Against enemies who pursue it into its den this structure also presents an effectual defense, for, while an enemy naturally would rush downward into the first direct passage, the spider may escape by the lateral branch. Supposing that the enemy, observing the mistake, ascends and follows along the branches, the spider has the opportunity to push up into the second branch while the pursuer, again following its natural instinct, would rush down the second perpendicular tube. I am here in the region of conjecture, but perhaps no better explanation presents itself.

2. Leptopelma's Complex Burrow.

A third stage in the development of this defensive industry is represented at Fig. 344, which shows the external tube of Leptopelma elongata.[1] This is simply a lily shaped tube of pure white spinningwork, rising directly above the burrow, and supported by surrounding foliage. The purpose of this structure has not been positively determined. As able a naturalist as A. R. Wallace has conjectured that it may be deceptive in its uses, its resemblance to a flower attracting to it insects, which are thus preyed upon by the proprietor. Such elevated objects are certainly apt to attract insects, who are disposed to alight upon them even without regard to their promise of providing food. But I am inclined to believe that Leptopelma's silken lily serves as a watch tower from which she can observe the approach of enemies and make good her escape in time. Moreover, I believe that it is possible for her to pull together the sides of the sheeted turret and thus erect a barrier between herself and some of her feebler pursuers.

3. Silken Aerial Tower.

Another form of defensive industry is presented at Fig. 345, which is the exterior part of the turret tube of Dolichoscaptus inops Simon. This is about an inch in height, and is composed of mingled chippage and mud, a sort of débris of chopped straw and soil.

4. Conglomerate Tower, Doorless.

A still further stage is shown at Fig. 346, which represents a columnar turret of Dolichoscaptus latastei several inches high. This resembles the tower of the preceding species, but adds thereto a hinged covering after the manner of the trapdoor. This turret is also composed of chippage and débris of various sorts gathered from the neighborhood, and is supported upon the surrounding foliage, which in the drawing is a plant of Lavandula dentata. All the uses to which such an elevated structure can be put are served by this ingenious structure, and, in addition, the trapdoor is manifestly intended to defend the inmate from the assault of enemies.

5. Trapdoor Tower.

We come now to the trapdoor nests of Nemesia meredionalis, and other

[1] Cyrtauchenius elongatus; see Volume I., page 322, Fig. 304.

species making traps of the wafer type, as so fully described by Moggridge. Here we have simply a dropping away of the turret of Dolichoscaptus and the use of the burrow independently of the same, but with the trapdoor retained. In the species studied by Moggridge a single burrow is the ordinary rule, but there are many variations, some of which are manifestly characteristic of species, and others which are probably occasional and accidental.

6. Burrow With Wafer Door.

A variation described by Mr. Simon is shown at Fig. 349, the nest of Stothis astuta, which inhabits the forest of Cartuche, near Caracas, South America. The drawing shows a section of the burrow, indicating the curved course, and also the two wafer like trapdoors habitually placed at either end. That this peculiar industry is defensive is probable, for we can readily imagine the spider disappearing within its den at one door, and, if its pursuer should succeed in entering the same, escaping at the other. We might, without much stress of imagination, carry the conception a little further, and suppose again the enemy making its exit from one door and the spider again descending

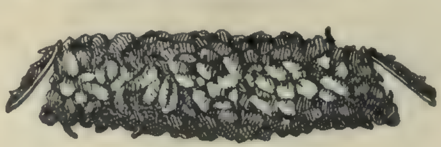


Fig. 347.

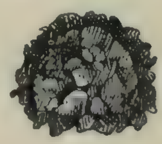


Fig. 348.

Fig. 347. Silk lined case of Stothis astuta, with two doors.
Fig. 348. Front view of a door.

into its burrow by the other. This game of bo-peep might evidently be played to the great advantage of the Trapdoor spider and manifest disconcerting of its enemy.

Simon gives an interesting example of the ability of a spider of this species to change its habit and adapt its industry to unexpected surroundings. The species commonly seeks dark and damp localities, and digs in vegetable earth a burrow not very deep. The nest, which is drawn in side view at Fig. 347, and a front view of the door shown at Fig. 348, was begun underneath a stone in soil which was so rocky as to be impenetrable. Not wishing to change its site, and not to be cheated out of its proposed domicile, Stothis proceeded to erect a cylindrical case about two inches long, composed of a conglomerate gathered from surrounding particles of soil and vegetable chippage. These were cunningly wrought together, the whole structure silk lined, and the characteristic trapdoors hung, one at either end. Thus, while varying her habit in so far as to build a surface tunnel instead of a subterranean one, Stothis preserved her defensive habit of erecting for herself a back door by which she could retreat in case of invasion at the front door.

Fig. 350 represents the burrow of Stothis cenobita Simon, which is

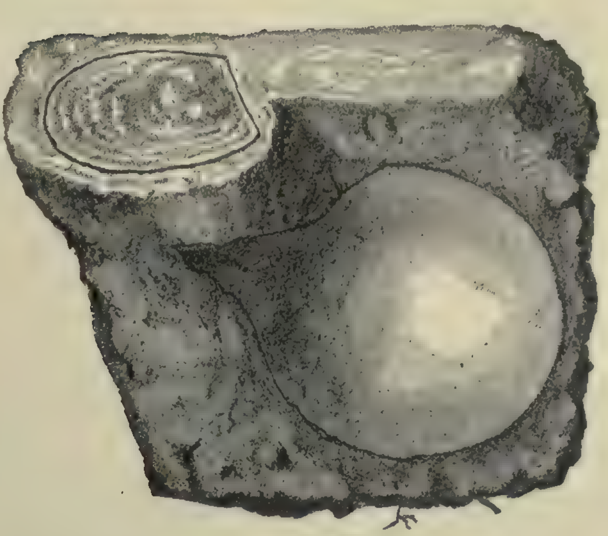


FIG. 350.

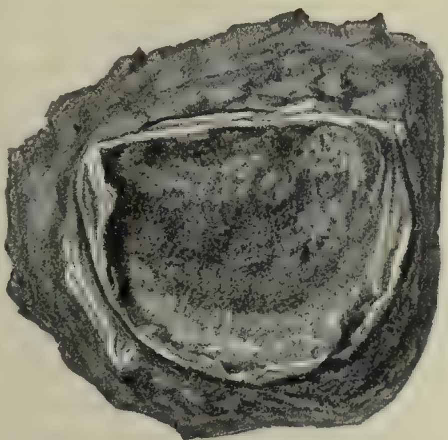


FIG. 349.

FIG. 351.

FIG. 349. Section view of curved burrow of Stothis astuta, showing double trapdoor entrance. FIG. 350. The globular burrow, with trapdoor of Stothis cenobita. (Section view.) FIG. 351. Front view of trapdoor. (Natural size.)

simply a rounded chamber underneath the surface and closed by a trapdoor, Fig. 352, which differs in no particular, as far as I can observe, from the ordinary trapdoor of the American Cteniza californica. (See Fig. 240 B, page 183.)

7. Burrow With "Cork" Door.

It is difficult to say what may be the enemies of the Trapdoor spider against which such ingenious architecture has been reared and such vigilant watch is exercised. But the quite general testimony is that these spiders leave their tubes at night and go forth in search of prey; or, as in other cases, open the lids of their tunnels and spread straggling lines near by, upon which passing insects are entangled and delayed long enough to allow the spiders to pounce upon them from their open caves. If we credit these accounts we might infer that the enemies which the Trapdoor spiders most dread are not such as are abroad at night. Evidently the creatures are fearless at that time, a state of mind which doubtless results from their knowledge that they are comparatively free from their worst enemies. The enemies which they most dread may therefore be reasonably looked for among diurnal creatures, and not among those of nocturnal habits.

FIG. 352. Trapdoor of Cteniza californica (natural size), to show the claw marks on the silk lining.

Among these foes at least one of the most formidable and irresistible is a diurnal insect, the female of the terrible Digger wasp, which I do not doubt will be found to store Trapdoor spiders, as well as Tarantulas and Lycosids. There is no evidence known to me that Pepsis formosa invades the tunnel of the Mygalidæ in order to dig them out. Such an act is not indeed beyond her powers, and, reasoning from the conduct of Elis 4-notata, it is highly probable. But we are not yet warranted in attributing the habit to her. Some lizard or mammal that might pull open the trap with its claws may be looked for as also a probable enemy against which Trapdoor spiders erect and defend their ingenious barrier.

At all events, the spider herself is well aware of these enemies. Abbe Sauvages invariably found, when he attempted to open the door of the nest of "the Mason spider" (Nemesia and Cteniza), that the mother was on guard, holding down the lid of her tunnel with great force. In his efforts to pull the trapdoor up the spider would jerk it down again, and

there would be an alternate opening and shutting of the nest until his purpose was accomplished.[1]

It is the habit, according to Moggridge, Simon, and all observers who have noted the point at all, for these animals to hang back downward upon the inner surface of the door. In many nests which I have seen there are holes along the outer or free edge of the door—the part directly opposite the hinge—which mark the points at which, probably, the fangs of the spider had been fixed, in order to give it a strong purchase against intruders. These holes are usually three, and show with great distinctness, even in the photograph from which Fig. 352 was drawn, which is the upper part of the nest of our California Trapdoor spider, Cteniza californica.

XII.

One of the most remarkable developments of industrial skill under hostile influences is that described by Moggridge in the inner door of Nemesia congener.[2] The general character of the nest is that of a tube ten or twelve inches long, drilled horizontally into the side of a slope, and closed outside with a wafer door. This horizontal burrow bends abruptly, and is continued perpendicularly downward, with a short branch extending upwards towards the surface. At the juncture or bending is suspended a wedge shaped double door, which tapers from below upwards to a hinge. The door has two crowns, separated from each other by the gusset like web of silk that connects the door on either side with the lining of the main tube. One of these crowns fits into and closes the main tube, while the other fits into the aperture of the upward branch. This swinging door acts very much in the fashion of a valve, dropping down to close the entrance from the first to the second tube, and swinging upward in such a way as to protect the spider when it is cowering within the upper branch of the perpendicular tube. The wedge like structure of this door is seen not only in the adult spider's nest, but in even more exaggerated shape in the nests of the younger ones.

FIG. 353.

FIG. 354.

FIG. 353. Cyclocosmia truncata. FIG. 354. Side view of same (After Hentz.)

[1] Cuvier, Animal Kingdom, Lond. ed., Vol. XIII., Supplement, page 465.

[2] Trapdoor Spiders, Supplement, page 223 and pl. xvi.

Mr. George T. Atkinson, who has given some attention to the American Territelariæ, dissents from Mr. Moggridge's supposition that this and other inside doors affords the Trapdoor spider a means of escape when pursued by an enemy, the view which I have favored in the foregoing pages. Mr. Atkinson, on the contrary, found indications that the main tube of Myrmeciaphila foliata[1] is constructed to serve as a gallery for the passage of ants or other insects, and that the branch so constructed is a real trap in which the spider awaits the passing of an ant, when it opens the door and catches the insect. In support of this opinion, he states that he found that the trapdoor nests were all made in places where ants had underground passages; that the main tube connected directly with some of the ant galleries; that the trapdoor at the surface of the ground had the appearance of being little used; and, finally, that one nest had only one door, which led into a short tube that opened into the floor of a broad hall in an ant's nest leading into several galleries. This hall was the gangway to the surface of the ground made by the ants, and through this the spider probably entered the hall to construct her branch tube into the floor.

Again, in May, at Chapel Hill, North Carolina, Mr. Atkinson found a nest of the same species under conditions which seemed to give conclusive evidence that the main tube is intended to entrap unwary insects as they pass the door of the branch where the spider lurks. This nest was made in a broad foot path where the clay soil was very hard. It was discovered by seeing the open door. The following day Atkinson visited the place with trowel in hand, to take up the spider. He found the door still open. The main tube was about nine inches long; the branch about one inch long, situated six inches from the surface of the ground. In this the spider was found. The door to the branch was a "cork" door, that is, a thick beveled one, while that at the surface of the ground was a "wafer" or thin door. It appears in cases where the spider's tube is not made in the ant's nest, that the outer door is set open, thus offering an attractive place for insects crawling on the surface of the ground in search of food. They enter the main tube and, as they pass the branch, the door is suddenly thrown open, and to their surprise they are taken captive and made a meal of by the cunning spider.[2]

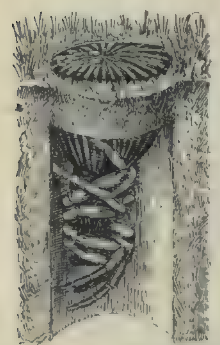


Fig. 355. Diagramatic view of Truncata, closing her burrow with her abdomen.

There is no doubt that Mr. Atkinson is correct in so far as the burrow of the Trapdoor spider does serve as a true trap for the capture of ants. Mr. Moggridge shows this in the case of Nemesia cœmentaria. (See above,

[1] Entomologia Americana, October and November, 1886.

[2] Psyche, Cambridge Entomological Club, Vol. V., July–August, 1888, page 89.

Chapter XII., page 355.) Mr. Simon also attributes this use of the tube to the ants of northern Africa, particularly to Dolichoscaptus vittatus, which drives into the earth a horizontal burrow that is considerably contracted and bent towards the end in the form of a little cul de sac, which is full of the débris of insects upon which the spider has fed. In one locality this insect débris consisted almost wholly of the remains of Atta barbara, the well known harvesting ant of Palestine and the Mediterranean shores.[1] I do not see that the two facts are at all contradictory. The use of the silk lined burrow as a decoy for curious insects in nowise hinders it from being also useful as a defense against enemies of various sorts.

One of the most curious examples of relation of structure to enemies, or perhaps of the reaction of hostile environment and agents upon structure is found in a Territelarian spider, Cyclocosmia truncata.[2] This aranead, according to Hentz, dwells like others of its kind in cylindrical cavities in the earth. Though many specimens were found, he never saw any lid or closure to the aperture of its dwelling. The very singular formation of its abdomen, which is as hard as leather behind and is truncated to form a perfect circle, induced Hentz to believe that when in danger it closes its dwelling with that part of its body instead of with a trapdoor or lid. This conjecture, of course, needs confirmation, though it seems not improbable; and one may imagine the intellectual confusion of a pursuing enemy, which finds its prey suddenly disappearing within a hole in the ground, but which, when investigated, presents nothing but a level surface where certainly a hole ought to have been! The dorsal view of the spider is given at Fig. 353; the side view at Fig. 354; and a diagramatic section view of the creature is drawn at Fig. 355, as it probably would appear when closing up the opening to its burrow.

FIG. 356. FIG. 357.

FIG. 356. Theridium differens, much enlarged, grasping her cocoon when annoyed. FIG. 357. Cocoon nest of same. (Natural size.)

Another mode in which enemies may influence the formation of habit in spiders has been suggested by observing the manner in which certain Theridioids defend their cocoons. Theridium differens, a pretty little spider inhabiting leaves and foliage (Fig. 357), which makes a flossy round cocoon somewhat larger than itself (about a quarter of an inch in diameter), will grasp her cocoon in her mouth when annoyed by one's finger or by

[1] "Étude sur les Espèces de la Famille des Aviculariidæ," of North Africa. Actes de la Soc. Linn. de Bordeaux, Vol. XLII., 1888, page 11.

[2] Mygale truncata, Hentz, Spiders U. S., page 16, pl. i., Fig. 1.

disturbance of the surrounding foliage. (See Fig. 356.) Her first impulse at the approach of what she regards as danger to her offspring, is to seize the little ball and carry it away to another part of her snare, or simply to interpose her own person between it and threatened peril, or at least to secure it by her own personal possession.

Now, it has already been shown (see pages 119, 120) that certain species of Lineweavers have acquired the habit of permanently carrying about their cocoons in their jaws and under their legs. This is their method of protecting their offspring from assail of enemies. The same habit, with varying methods, prevails with certain Laterigrades, with most Citigrades, and perhaps also with some Tunnelweavers. May it not be that this fixed habit of protecting cocoons by personal possession may have originated from such occasional acts as that common with Theridium differens, and which, by transmission and gradual growth, have come at last to be characteristic?

CHAPTER XIV.

DEATH AND ITS DISGUISES, HIBERNATION AND DEATH FEIGNING.

The Decline of Argiope.

As one passes through the fields in the latter part of September or early in October he marks the cessation of activity on the part of Argiope cophinaria. The splendid creatures, whose restless vigor in spinningwork and ferocious activity in capturing prey were so apparent a few weeks before, have nearly all disappeared. The males have gone weeks before. Not one of the courtiers that were seen hanging around the outer courts of their lady loves' snares has survived the mating season. Occasionally one notes a female, a shrunken remnant of her former self, suspended in listless mood upon a tattered web, or crawling sluggishly around the circle of her orb, weaving in her spirals as though spreading a table for the last banquet that life affords.

A little further on one will see the dead forms of other individuals hanging in various postures from broken snares, or from tattered remnants of the silken shield, or from snatches of cross lines dangling from leaves and bowers. Still further, as one moves on, he sees fragments of the once beautiful snares stretched out at various points between the grasses and branches of low lying shrubbery. The strands flutter in the breeze. The great central patch of white silk flaunts like a tattered banner after a battle. The radii are snapped, the spirals have lost their viscidity, or have only retained them to capture hapless insects that expire without even the poor satisfaction of helping rejuvenate exhausted Nature by rendering their lives an offering to the vigor of another creature. The race of Argiope is gone for the current year.

Where are these noble araneads that so lately brightened and enlivened the landscape? They have crawled away into various nooks beneath embowering leaves or other cozy retreats, and there have woven the beautiful basket like cocoons which characterize the species. The last force of life has been expended in this act and, somewhere near, the dry and shriveled corpse of Cophinaria may be found hanging, after a little while, to the threads on which she perished, soon to be washed down by the rains of autumn and mingled with the dust beneath. When the warmth of spring has once more revived the earth, another generation will issue from these cocoons and go forth to follow the life round of the race that has now passed away. This record of the decline and fall of Argiope is a picture

FIG. 358. The fashion of death. Argiope cophinaria hanging dead in her snare, on an ampelopsis vine against a wall.

of what one may everywhere see of other species during autumn days, and, indeed, at other seasons also, for the limit of life with some species is reached before the fall.

I.

The Fashion of Death.

I have heretofore remarked that the most natural death of the spider is, perhaps, a violent one. To feed the hungry maw of a stronger, more skillful, or more fortunate fellow aranead; to be paralyzed and entombed within a clay sarcophagus by a mother wasp and serve as food for a growing waspling worm; to be snapped up as a delicate tidbit by birds, toads, and all the other creatures that prey upon her—these are some of the modes by which, in the appointments of Nature, the spider meets that doom which must befall all the living. And a painless doom it doubtless is, even thus.

But there are some that end their life by what we commonly call a natural death; that is to say, they do not perish through violence, but cease to live because of the natural exhaustion of vital forces. It is one of the most difficult matters, among the many difficult ones in the study of spider life, to find an uninterrupted opportunity for consecutive observations of a spider while undergoing this fashion of death. But I have been fortunate enough to create opportunities which have afforded me satisfactory results. Most of the examples studied were females of Argiope cophinaria, which I had colonized upon the vines in my manse yard. One of these, called for convenience Prima, had occupied a position upon a honeysuckle vine for several weeks, and highly enjoyed herself capturing and devouring numerous flies attracted to the spot from a neighboring stable. The first stage of mortality was simply a condition of inactivity.

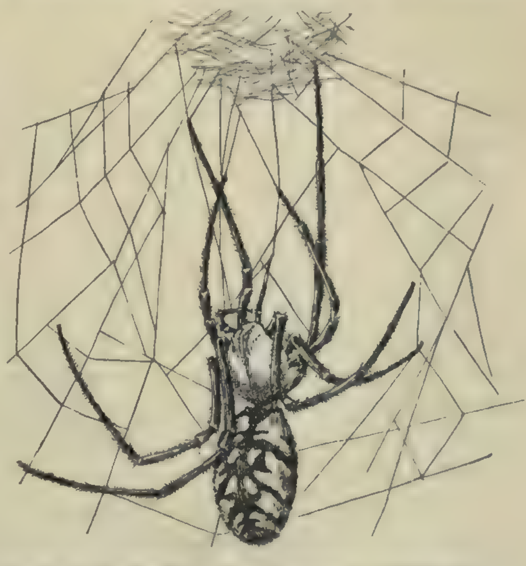


FIG. 359. The death fashion of Argiope. Position of Prima just after death.

In my daily rounds among my pets, I noticed nothing peculiar in Prima except that she seemed to be hanging inactive behind her central shield of white silk. But as this is not an unusual circumstance, it attracted no special attention until September 24th, when I found her hanging in a position that at once indicated disaster. I touched her and tried her sensibilities in various ways; but she was dead. She had, indeed, evidently died

upon her web unnoticed by me. Now she hung behind her orb in the position represented by Fig. 359. Only a scant patch of the central shield remained. One hindermost foot was extended upward almost straight from the cephalothorax, and grasped the ragged edge of this patch. The corresponding last leg on the opposite side of the spider was outstretched in a like position and held to the opposite portion of the ragged shield. The third legs on both sides were holding to straggling threads. The second legs were curled forward towards the snare behind which she hung, and the claws held to cross lines of the notched zone. The first pair of legs hung free, and were projected through the meshes of the snare. Thus, even in death was maintained the habitual position of the creature when watching for a victim or an enemy, the first pair of legs being kept free in order to feel towards and find contact with an object of desire or dread. Between the patch of silken shield and the parts of the snare immediately beneath was a great gap, the size of the spider's body, which had evidently been produced by the weight of the creature as she hung downward. The whole web, indeed, was relaxed in all its remaining parts. The abdomen of the spider hung downward at an inclination from the cephalothorax of perhaps forty-five degrees, in which position it was held by a trapline attached to the spinnerets and at the opposite end of the ragged shield.

First Stages of Mortality.

The next day, September 25th, the position of the spider was substantially the same. September 26th the first and second legs were bent over towards the body, and the claws seemed to have entangled with portions of the cross lines. The palps were as at the time of the first observation, one stretched out holding a thread by the palpal claw, and the other bent over a line, as one would bend his arm across a rope by which it was supported at the bended joint. By September 28th the web which had been gradually sinking was quite sagged down behind the vines, and but few portions of it remained; but upon lifting the leaves, the spider was seen hanging, but with the legs considerably more procurved. One fore leg, however, was still stretched out straight, and held to the drooping line by the clasped claws.

"Finis!"

There is little to detail concerning the subsequent history of the deceased Prima. I watched during the first week of October, and saw the various fragments of the orb frayed away by the winds and rains, which were quite severe. But the corpse hung in the position last described, the one outstretched leg strained to high tension and supporting the whole weight of the body. When last seen, the remaining legs were rigidly bent at the joints and clustered together over and around the head. October 8th the spider had disappeared, dropped down or washed down by the rains into the mass of leaves and tendrils below, no doubt, although I could not find it. Thus the chapter ended; a seemingly quiet, gradual, painless death; a winding sheet among the leaves like an ancient Egyptian

mummy, and a sepulchre amid the tangled tendrils of fragrant honeysuckle. Not an undesirable kind of death and burial.

The second example, the Secunda of my notes, hung upon an ampelopsis vine against the chapel wall. I quote my journal: " . . . . For two days, September 28th, she has hung absolutely inactive. Yesterday I touched her, and she only slightly moved her fore legs, then sank back into position. She is entirely natural in her appearance, and no one observing her would suspect that anything is the matter with her. This morning I put a vibrating tuning fork to one of her legs, and the only sign of animation she gave was slowly but slightly drawing the legs towards her. Under ordinary circumstances this act would have produced the wildest excitement. At four of the afternoon I repeated the test, and action seemed to be a little more decided. The fore legs were curved inward, and an hour afterward were not relaxed again. I then touched the spider with my finger, and she drew her legs up a little closer, making no further sign. . . . . September 29th. Secunda has left her position on the shield, crawled along the stem of an adjoining leaf, and is hanging with her back downward and her feet clasped around the stem close up against the wall." (Fig. 360.)

FIG. 360. Death fashion of Secunda.

For a week thereafter the record continued with little variation, except that Secunda would shift her situation a little, several inches to one side, and above or below. Once after long hunting I discovered her by seeing her swing down by a thread between my hands. She dropped six or seven inches, climbed up the thread sluggishly, and resumed position with her feet clasped above the stem. I never could find her again. She had doubtless nestled out of sight and died in the fashion she had habitually maintained during the few days immediately preceding her disappearance.

FIG. 361. A dead Argiope hanging in her snare. (Sexta.)

Another example may be cited from my journal. It was followed up so closely and continuously that it well illustrates the manner in which spiders pass away from life. The animal was sixth of my series, and noted under the name of Sexta. She was transferred from the banks of the Schuylkill River to

an ampelopsis vine upon the outer wall of my manse. For several weeks she hung in the normal position of her species, frequently changed her web, and occupied herself in the usual manner of spiders. During cold weather that occurred in the early part of October, 1888, she appeared to be a little torpid, at least was decidedly inactive. Throughout those days she would move her legs when touched by my finger or by a vibrating tuning fork, but showed little excitement. The last evidence of activity which she gave before passing into a lethargic condition was to move slowly to one end of her snare from the centre. The next day, October 4th, I found her with legs doubled quite over certain lines of her web, and rigid. There appeared to be a little life in her, but on the following morning, October 5th, she was hanging in the same position dead. (See Fig. 361.) The axis of her body was at right angles with the position in which the spider usually hangs; that is to say, she was stretched crosswise of her web. The limbs were all bent at the middle joints, in the angles of which the linework was looped. The spider appeared to be chiefly sustained in this way, although some of the feet were still attached to parts of the snare.

Sexta's Death Record.

Fig. 362. Sexta in dying attitude.

I continue the description by extracts from my note book: "October 6th. Sexta hangs in the same position. October 7th. Ditto. October 8th. Certain lines in the web have given way so that the fore part of the body has dropped downward, causing the spider to hang now in her natural position. (See Fig. 362.) The two pairs of hind legs are stretched out to their utmost extent, and the feet hold on mechanically to threads. The fore legs are bunched and bent, as in the first position, with very little change. The weight of the spider's body has evidently drawn out the two hind legs by which she is sustained. October 9th, 9 A. M. Sexta still hangs in the above position. No change observable. A cold morning and clear. October 9th, 6 P. M. The position of Sexta is now changed. The left hind leg is loose, the thread to which it held having been broken by the wind or by a dropping leaf. The claw still holds to the line, a broken fragment of which floats out from one side. The body has swayed quite over, and the abdomen is twisted into a position at an angle nearly forty-five degrees to the perpendicular. The other legs remain about the same, except that the fore part of the body is swung upward and to one side. Its weight is largely supported on the one outstretched hind leg." (See Fig. 363.)

From this date and up to October 22d, Sexta was observed every day, morning and afternoon. Although high winds and heavy rains prevailed

during this period, and the leaves were continually dropping from the vine, no change at all of any decided character occurred in the position.

"Finis!"

The lines maintained their strength and tension. The next day, however, showed a change. "October 22d. This morning the threads of Sexta's web have relaxed and broken, and the position is quite changed. The abdomen is shrunken up, a mere hard, dry shell. . . . . October 24th. Fearing that Sexta would be carried off by the high wind and falling leaves, and wishing to preserve the body, I removed it from its lines, and the shriveled corpse now rests in my collection at the Philadelphia Academy of Natural Sciences.

I have observed something of the same sort in spiders kept in confinement within my breeding boxes, where I had placed them for various observations, particularly to secure cocoons. I was sure to find them some morning lying upon the bottom of the box, quite shriveled up and dead. In the case of spiders after the act of cocooning, the process is very much as above described, so far at least as I can judge from disjointed observations upon various species.

After Cocooning.

Of course, those spiders which make several cocoons remained active until the last cocoon has been spun; but with those who make but one the forces of life seem to be entirely or largely expended in the act of maternity. After a little while the creature hangs to the maze of lines within which her cocoon is usually suspended, or to some bit of web adjoining, and then simply drops off dead. As she lies in this attitude the legs are usually bent beneath the body and towards the mouth parts. Sometimes they will be found clustered close together just beneath the mouth or some part of the sternum. The abdomen frequently shows gaunt and shriveled. In the case of the spiders above described, who had not made cocoons, the abdomen immediately after death was sufficiently plump, at least not shriveled. Some spiders, after the act of cocooning, have enough energy remaining to spin a web and even capture prey, but with the Orbweavers which make only one cocoon, this is the exception and not the rule.

FIG. 363. Sexta after death.

II.

Until lately little has been known concerning the possibilities of prolonged life among the lower orders of animals. The waste of life is great

in the natural conditions surrounding most inferior creatures, so that the immense fecundity of insects and araneads, for example, is abundantly checked. I have counted over eleven hundred eggs and young spiders in the single cocoon of Argiope cophinaria; yet, though a score of cocoons may hang in a field, one will scarcely find as many spiders as cocoons the next summer. In efforts to breed spiders from cocoons, I have at various times seen colonies numbering from

Limit of Life.

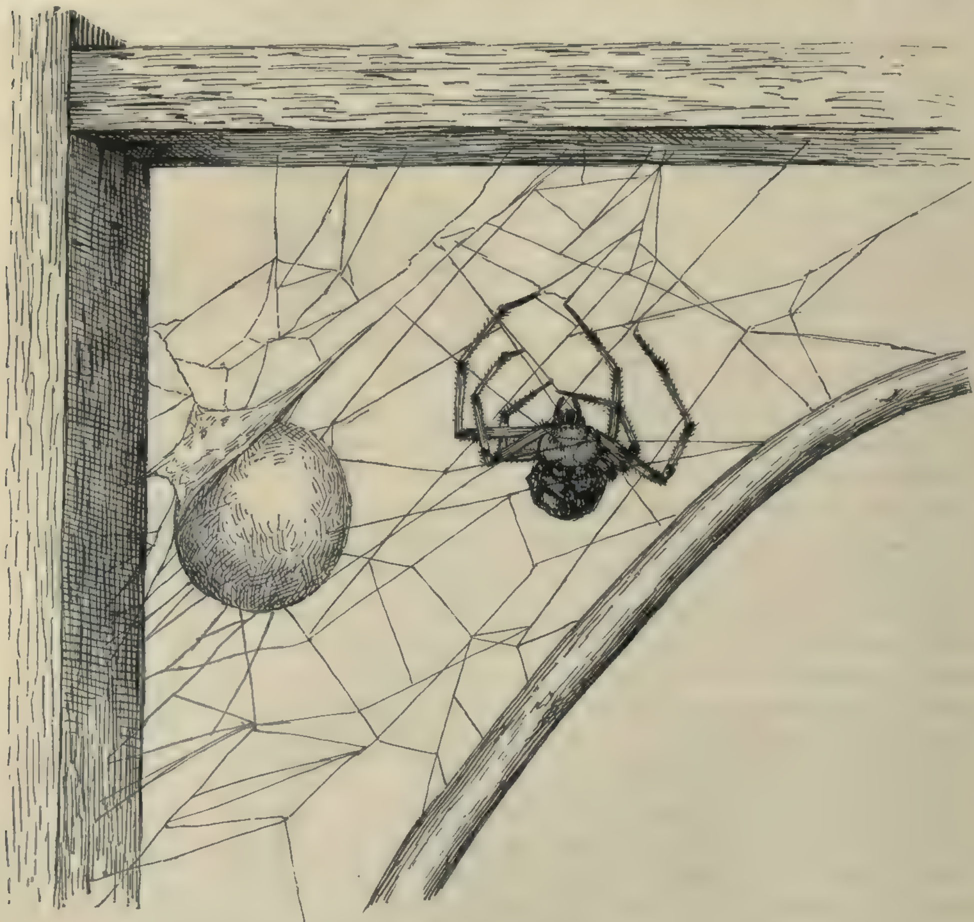


FIG. 364. Argiope cophinaria hanging dead beside her cocoon.

one and two to ten hundred dispersed from the maternal egg nest to surrounding foliage, of which during the year not a single survivor could be traced.

Bee keepers are well aware of the great mortality among working bees, caused not only by disease and accidents, but especially by those enemies which prey upon them. Ants are quite as much, perhaps even more exposed to loss from accidents, the exigencies of weather, and the appetites

of various insectivorous animals. There is, therefore, abundant occasion for the seemingly exhaustless fertility of the queen mothers of formicaries. These queens probably have a longer life than the workers. They are larger in size and apparently organized for more vigorous resistance of the influences which work for their destruction. Moreover, the instinct of the workers has provided a system of preservation by surrounding the queen with a guard of attendants which never leave her unprotected, which care for all her wants, and vigilantly separate her, by a regular system of seclusion within the portals of the formicary, from many influences which would prove hostile to health and fatal to life.

Lubbock's Old Ant Queens.

How long the ant queen may live in an entirely natural habitat is unknown, and perhaps cannot be determined. But recently, through the patience and ingenuity of Sir John Lubbock, we have learned that under artificial protection both workers and queens of certain species may attain a great age. Some eight years ago I had the privilege of visiting this distinguished naturalist at his country seat, High Elms, Kent, and examining under his personal direction his artificial formicaries, and the mode in which they are preserved. At that time I saw a queen of the Fuscous ant, Formica fusca, which was nearly eight years old. On the last day of July, 1887, I again visited Sir John at his house in London, and on inquiry after the aged queen, which I supposed to be still alive, was informed that it had died the evening before, having at the time reached the wonderful age of thirteen years.

I was permitted to see this venerable queen as she lay in death on the floor of one of the wide chambers which the workers had excavated in the soil compacted between glass plates that bounded their formicary. She was still attended by a circle of the "courtiers" which, according to my published observations,[1] are in the habit of watching continually upon ant queens. Some of these attendants were licking the dead queen, or touching her with their antennæ, and making other demonstrations, as though soliciting her attention or wishing to wake her out of sleep. "They do not appear to have discovered that she is really dead," remarked Sir John. And so, indeed, it seemed. It was certainly a touching sight to witness these faithful attendants, surrounding the dead body of one who had so long presided over the maternal destinies of the colony, and seeking by their caresses to evoke the attention which never again could respond to their solicitations.

In answer to a letter of inquiry concerning the life of this queen and her companion, Sir John wrote me[2] as follows: "As they had lived with me since December, 1874, they must have been born in the spring of that year. One of these queens, after ailing for some days, died on the 30th of

[1] Honey and Occident Ants, Chapter IV., page 41, plate vi., Fig. 29.

[2] Under date of May 10th, 1890.

July, 1887. She must then have been more than thirteen years old. I was at first afraid that the other one might be affected by the death of her companion. She lived, however, until the 8th of August, 1888, when she must have been nearly fifteen years old."

This longevity is, as far as I know, unparalleled in the history of invertebrate animals. Such experiments as the above clearly indicate that artificial environment may have a beneficial influence upon insects as well as domestic animals, and that the interference of human intelligence may be a preservative factor, as well as a destructive one in the lives of even our most lowly organized fellow creatures.

The Oldest Spider.

Early in the year 1882 I received from Dr. Joseph Leidy a specimen of our common tarantula, Eurypelma hentzii.[1] As the individual seemed to be in good health, I preserved its life in order to gain information as to its habits and vital endurance. It was first placed in a large glass globe on a bed of earth, where it was kept for more than a year. It was then transferred to a wooden box made with glazed sides and a sliding glass door at the top, the whole being eighteen inches long, twelve inches wide, and ten high. One end was filled with dry soil, which was slightly compacted and heaped up; the other end was sparsely covered with earth. There was thus presented a bit of level space for the spider to burrow should it be inclined to its natural tastes. I last saw it early in July, just prior to my departure for England. On June 22d, 1887, I made this note: "This spider, which has been kept ever since 1882, is to-day in good health. It is on the outside of the earth moundlet in its box, looking hearty after the winter's fast. It has had nothing to eat since October last—at least eight months—but has had water freely. Some flies have been put into the box lately, but I do not know that they have been eaten." The spider was then left in the care of Professor Fronani, who for several summers, while at work in the library hall of the Academy, had kindly cared for it during my absence, giving it water and feeding it with insects, particularly grasshoppers or locusts.

On my return from abroad I was met at the Academy by the intelligence that my tarantula was dead. About the close of July it had descended into the burrow which for several years it had maintained close to the side of the box, and since then had not come up. Looking into the box I could see against the glass the fragments of a moulted skin on one side of the cavity, and on the other side the outlines of the creature's dead body. It had evidently died shortly after moulting.

Reckoning its death as having occurred at the close of July, 1887, the

[1] It was captured about the beginning of April, 1882, at Hills Ferry, Stanislaus County, California, was kept in a bottle without food for two weeks, then sent to Professor G. E. H. Weaver, at Media, then a student in Swarthmore College. Mr. Weaver fed it on beefsteak, which it took readily.

spider was five years and three months in my possession. I have not sufficient data to estimate accurately the rapidity of growth in this species, but judging from such facts and indications as I have observed the animal must have been from eighteen months to two years old when I received it from Dr. Leidy. At the period of its death, therefore, it must have been at least seven years old, and may have been eight or more. It thus attained the distinction of having reached the greatest age of any spider known to science. How long this species and members of the Theraphosidæ generally live in their natural habitat is of course unknown. I have little doubt that they live much longer than other tribes, but am inclined to think that it is not usual for them to reach such an age as my tarantula "Leidy." In its case, as in that of Sir John Lubbock's queen ant, human protection probably prolonged life.

Tarantula's Age.

Other observations on the age of spiders fall in with this indication of their vital endurance from the tarantula's prolonged age. Blackwall kept spiders of the species Tegenaria domestica and T. civilis to the age of four years.[1] Moggridge made a calculation of the age of Trapdoor spiders, based on average growth in nests of the young; for he established the fact, which has subsequently been confirmed, that a young spider, instead of abandoning its nest, enlarges it with its growth. He concluded that it took at least four years to produce a full size trapdoor nest, and, of course, the architect must be at least that old.[2] The most recent information on this point is from Mr. Frederick Enock.[3] This observer, in an extended and interesting communication on the habits of the British Atypus, speaks of one individual which he kept over three years, and which, judging from its size when first captured, he puts at the age of six years. Other examples, under observation for more than two years, were well grown when first transferred to his artificial colony, and at the date of his paper, June, 1885, were still in good health. He ventures the inference that Atypus is about four years in reaching maturity; then retains her young for eighteen months under her care before turning them out to shift for themselves, and after that lives in vigorous health for a period which he believes may sometimes reach the advanced age of ten years. Thus, a spider's life may vary in length, according to organization and surroundings, from a single season to two, four, and even eight or ten years.

Great Age of Atypus.

I may add here, as in the same line of research, that Dr. George H. Horn, a distinguished authority in the Coleoptera, has called my attention to the fact that a female of Cybister roeselii was preserved for eight years of continuous life by Dr. David Sharp.

[1] Spiders Gr. Bt. & Ir., page 8. [2] "Harvesting Ants and Trapdoor Spiders," page 127.
[3] "The Life History of Atypus piceus Sulz.," Trans. Entom. Soc., London, 1885, page 416.

III.

If one will go to any woodside or other spot where the foliage of trees and vines has been amassed, and examine one after another the withered leaves, he will have opened to him a new and interesting chapter in the life of spiders. This process is familiarly known as "sifting," and it is an admirable method of collecting in the late autumn, winter, or the early spring. Clear away the mass of snow overlying that windrow of withered leaves, fill a generous basket full, and carry them into your study. Open carefully the curled leaves one after another, and you will find a number of spiders of various species, that have found their winter refuge and rest within these seemingly inadequate receptacles.

Winter Habits.

Here are Saltigrades, nested within their white, thick, silken cells. Here are all sorts of Tubeweavers, Disderids, Drassids, Agalena, Tegenaria, Dictyna. Some of them are underneath silken cells, others clinging to simple strings of intersecting lines. If the weather be very cold, most of them will be found quite torpid; but in the warm atmosphere of the room they will soon renew their vitality and freely creep about. If the temperature be mild, or if the sifting be made at that part of the year which lies just between winter and spring, the spiders will have recovered from their hibernation, but many of them will be certain, as soon as they feel the touch of the inquisitive observer, to double themselves up in that strange mimicry of death which marks so many species.

Such an examination as the above has increased my surprise at the immense host of spiders that must be preserved throughout the winter by nestling under leaves and forest mold. The autumn broods of younglings here find refuge in numbers, and when the snows have been melted away by the south wind and the increasing heat of the sun, they creep forth from their leafy lairs and enter upon the active duties of their lives. Nearly all species in all the several tribes thus find winter homes in such places. This is not only true of the woods and wild fields, but of the lawns, groves, and parks surrounding suburban and city homes. When the bright, soft days of April come, and the gardener begins his annual task of raking withered leaves together and burning them, my heart has many a spasm of pity at the reflection that this seemingly harmless and necessary work is the holocaust of millions of hapless spiders. Thus, even in the discharge of ordinary duties, man is unconsciously one of the most destructive enemies of the children of Arachne.

Hibernating in Leaves.

A good time to uncover the winter habits of spiders in the latitude of Philadelphia is the early or middle part of April. Frequently there will come a few successive days of warm sunshine, particularly if the preceding winter has been mild, that invite the Sedentary spiders from

their lairs, and tempt them to spin their first webs. These webs betray their winter quarters. Here, for example, along these hedge rows of arbor vitæ are a number of round webs whose proportions indicate mature weavers, and whose construction gives the experienced eye a token that Epeira strix has probably spun the snare. She is not upon her orb at this hour of the day, and is doubtless resting in some secluded spot near by, which spot, considering the season of the year, is almost certain to be the den within which she hibernated.

Epeira's Winter Den.

The tyro spider hunter would vainly search along the hedge row for this refuge, but certain signs which experience has taught lead one to a particular point, where a larger concentration of threads, diverging from the foundation lines of the orb, form a sort of guide board to the desired haven. Follow this clue, gently separate the sprigs of foliage, and push aside the twigs, and one will see a few inches below the surface, at a point where the branches diverge, a mass of rubbish. It is accumulated between the forks of the twigs, and has been retained in its position by the same. These leaves have dropped from the bush above, and have drifted in from surrounding plants. It is possible, also, though I cannot affirm it, some of the material may have been collected by the spider and added to the nucleus which accident furnished. At all events, here is a lump of rubbish as large as a hen's egg. The whole is lashed together by scant threads of spinningwork, which assist the office of the encompassing twigs, and brace it in its place at the point of juncture.

If one thrusts a finger beneath the mass, a slight opening will be found, which is manifestly the door of the den. Now, with fingers or scissors, separate the ball of rubbish, and lo! inside, snugly ensconced in the very heart of the heap, is the weaver of the web and proprietor of the den, our interesting friend Epeira strix. Here she has lived throughout the winter, and, as she is entirely mature, she must have been well grown when she first went into winter quarters. One day (April 14th), while walking with my secretary, we found a number of these nests within a short space in the precincts of Woodland Cemetery, on the banks of the Schuylkill River. Several mature females and one mature male were discovered, all of them occupying some sort of a den of miscellaneous rubbish, gathered together with varying degrees of efficiency. With the compact roof of evergreen leaves, which forms the outer surface of the plant, stretched above the den and serving as a screen from snow and frosts, it is evident that this winter nest is a safe or at least sufficient refuge for the Orbweaver.

Another favorite winter resort for spiders is the stump of an old tree; another, the hump of earth and roots which marks the spot where a tree has fallen. Every hollow and cranny forms a refuge for some species. Favorite spots are the tubes or "casts" beneath the soil formed by decayed roots. Tearing away the earth at this point, for example, one finds the

soil penetrated by a well rounded pipe, whose walls are protected by the outer bark of a root. Only that remains. All the rest has perished, leaving a long tube in the earth wherever the root had run. Here many spiders have found winter refuge, and from the mouth of one of these natural dens a full grown specimen of Tegenaria medicinalis is unearthed.

Other Winter Resorts.

Young spiders survive the winter in the admirably arranged cocoons provided by the maternal instinct. But early in spring many adults of both sexes are found nearly full grown, that have also safely weathered the cold months. I have at various times in the winter collected Epeira strix, and have found the species adult in spring. Specimens of Strix may be frequently taken during winter months from rolled leaves within which they have withstood our hard frosts. These rolled leaves also serve for nests during summer. Dr. George Marx has informed me that on the capacious Government grounds in Washington City he often sees such curled leaves suspended, conspicuous amid the verdureless branches, and has learned to recognize them easily as the winter quarters of this species. It of course follows that, either from purpose or by the accidental enwrapping of threads during continual journeys back and forth, trailing her dragline behind her, she secures the leaf from falling.

Winter Tent of Leaves.

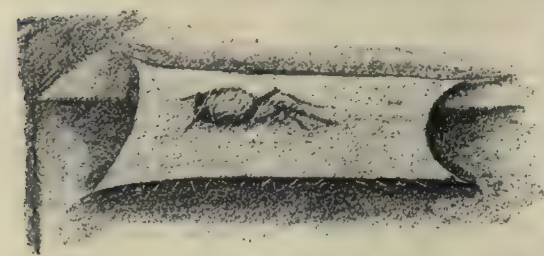


FIG. 365. Arched shelter tent for winter service.

A vast colony of Epeira sclopetaria inhabits the boat houses grouped around the inlet at Atlantic City.[1] I visited this colony in the latter part of May (1882), when the season had been remarkably backward, cold, and rainy. The trees on the island had not yet leaved; insect life had scarcely appeared; in short, the season had advanced little further than the first of May in ordinary years. The inlet colony, however, had already appeared in large numbers, and had swung their orbs between the timbers of the houses and the piles which supported them. These were of various sizes, full grown, half grown, and young several weeks out of the cocoon. All the cocoons, which were thickly laid along the angles of the joists and cornices, were empty. The number of young spiders was, however, remarkably small, a fact which I could account for only on the supposition that in the absence of the usual insect food supply the adults had been driven to prey upon the young, and the young upon each other to an unusual degree.

Many of these spiders were hanging in the centre of their round snares.

[1] See page 232 and Fig. 256.

Others, the greater part indeed, were covered within a thick tubular or rather arched screen (Fig. 365), open at both ends, which was bent in the angles of the woodwork, or were sheltered beneath an irregular rectangular silken patch (Fig. 366) stretched across a corner. Many others were burrowed behind cocoons quite covered up by their thick, flossy fibre, in which condition they had undoubtedly spent the winter. I have found examples of Epeira strix blanketed in precisely the same way during the winter months. I asked some of the young boatmen what the spiders did in the wintertime. "They crawl into their bags," one answered, referring to the screens and tubes above described (Figs. 365 and 366), "and stay there. They came out about a month ago (the last of April), and then shed. A couple of weeks ago the sides of the houses were all covered with these sheds." "Shed," it should be understood, is vernacular for "moulted" or "moult."

English Orb-weavers.

English spiders have like habits. Epeira apoclisa frequents gorse, heath, and rank herbage growing near marshes, lakes, pools, and brooks, or other damp situations, among which it constructs a dome shaped cell of white silk of compact texture. In this cell, after distributing upon its exterior surface the withered leaves of plants, and enclosing its entrance with a tissue of silk, the spider passes the winter in a state of torpidity.[1] It is said that Apoclisa possesses the power of closing the door of her nest against intruders by seizing the sides with its claws. The eggs are placed in her cell, enclosed in several slight, roundish, yellow cocoons about half an inch in diameter. Similar nests attributed to Epeira quadrata, although Staveley[2] thinks the deserted nests of Epeira apoclisa are alluded to, are selected by the dormouse, according to Rennie, as a ready made roof for its nest of dried grass. That the old spider dens are not accidentally chosen by the mouse appeared from the fact that out of about a dozen mouse nests of this sort found during winter in a copse in Kent, England, every second or third one was furnished with such a roof.[3]

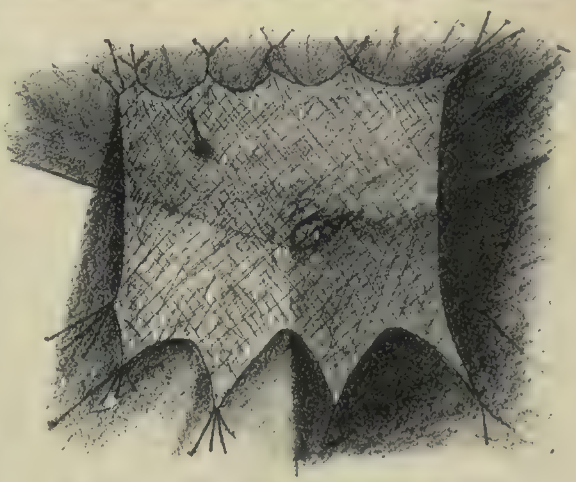


FIG. 366. A winter bivouac tent of Epeira sclopetaria.

[1] Blackwall, Spiders Gt. Br. & Ir., page 321. [2] British Spiders, page 230.
[3] Rennie, "Insect Architecture," page 109.

The winter habits of the Retitelariæ are various. Many of them creep into hollow trees, into holes and crevices of divers sorts, or spend the winter under fallen leaves and in vegetable mold. Many of them have great powers of endurance, and in the neighborhood of houses, barns, and outhouses may be seen in the coldest weather simply snugged up against a corner or angle of wall or woodwork, with a few straggling lines beneath them, taking the cold weather without any protection or attempt to secure such. Tubeweavers, with few exceptions, find their winter homes among leaves and forest mold, in hollow roots, deep crannies, in rocks, underneath stones, and like positions. These are also common winter resorts of Laterigrades and Saltigrades, although they prefer lodgings underneath old bark. But the latter always spin around themselves a tube of thick silk, which serves them as a blanket. On a warm day in winter these vigorous little creatures may sometimes be seen jumping about upon the surface of the snow, having been attracted by a patch of sunlight pouring upon their winter dens to try their fortunes at winter hunting.

Line-weavers and Other Tribes.

The Lycosids, without exception, as far as I know, spend the winter in earth burrows. One example of Lycosa tigrina observed by Mrs. Treat made but little change in the dome shaped covering of her burrow until November, when it was cut down level with the ground, perfectly concealed with leaves and moss, and held firmly down with strong webs. This covering remained until the following April. In spring, the gardener, not knowing that this spot was set apart for special study, raked away the leaves and rubbish, preventing observation of the manner in which Tigrina herself would have removed her winter covering; but in a few days thereafter she had made another cover, not like the flat winter thatch, but more like a little room.[1]

There is much to learn concerning the life history of Lycosids, and it may be yet found that their winter life shows a greater activity and variety of habit than has generally been supposed. It is possible that they may not remain enclosed within their burrows during the entire winter in a state of semihibernation. Dr. Allen Gentry, a careful observer, informed me that he observed this incident while visiting a frozen pond in the vicinity of Philadelphia. He cut a slab from the ice, about eight or ten feet from the bank, and was surprised to see spiders running about in the water. They were passing from point to point by silken lines stretched underneath the surface between certain water plants. Several specimens were collected, but unfortunately were not preserved. They were supposed to be Lycosids, and, from Mr. Gentry's description of the eyes, his supposition is evidently correct. It is a remarkable and notable fact that these creatures can thus live in full

Lycosids.

[1] Am. Naturalist, August, 1879, page 488.

health and activity, within the waters of a frozen pond, in midwinter, and so far from the bank in which their burrows are commonly found. It has been believed heretofore, and doubtless it is generally true, that Lycosids winter in deep burrows in the ground, sealed up tightly to maintain a higher temperature. But the above observation opens a new and strange chapter in the winter behavior of these araneads, as well as in the amphibious nature of their habits.[1]

IV.

Hibernation.

The effect of low temperature upon spiders was observed in several young specimens of Theridium tepidariorum. They hung on a few short lines to the plastered wall of a brick building on my premises, the plaster being laid directly on the brick, forming a cold surface. The spiders were protected from wind and snow, but wholly exposed to the frost. On January 14th (1885), with thermometer ranging from 20° to 25° above zero (Fahrenheit) the spiders were hanging motionless. When touched by the tip of a pencil they dropped down in the usual manner of their kind, holding on by the outspun threads, which reached a length of over one foot. They ascended to their perch afterward, and crawled over the roof for a short distance.

At a temperature of 18.6° they again were able to drop from the perch. January 19th, with the thermometer ranging from 17.5° to 20°, they seemed less active; one individual, when touched, dropped about one inch, another six inches. Four hours thereafter they were suspended in the same position and place. As the natural habit of the creature is to ascend in a moment or two after disturbance, this shows that the frost had affected the normal energy. One of the specimens, however, on being gently lifted upon my finger, moved its legs and very slowly began to ascend. Five hours thereafter it was at its perch against the roof. These spiders, at this temperature with some variations (January 21st), moved their position, one passing along the angle of the roof a distance of four feet. This change of site was probably caused by the annoyance which my experiments produced.

Sudden Resuscitation.

February 11th the thermometer stood at zero; in West Philadelphia, where my observations were made, the temperature was lower. On the 12th the Signal Service reported 1° above zero, at my house it was below zero. On this day I removed from its position one of the specimens, a young female about two-thirds grown, and placed it in my library, where the temperature was summer heat. She was put upon a table in the sunshine, at which moment her legs were drawn up around the cephalothorax in the usual hunched way when torpid or feigning death. There was a slight and regular pulsation

[1] Proceed. Acad. Nat. Sci., Philadelphia, 1884, page 140.

of the feet. In less than ten minutes, upon being touched, she stretched forth her legs and began to move slowly over the paper upon which she had been placed. When touched, her motion was much accelerated, and she began vigorously to perambulate her bounds, meanwhile anchored to and pulling out after her the usual dragline. When lifted up on the tip of a pencil, she spun out a long thread, to the end of which she hung in the little foot basket of silken cords which I have elsewhere described. Indeed, her action was in every respect normal, and showed a remarkable, sudden, and complete renewal of activity after so long an exposure to such extreme cold.

February 26th, a younger specimen, about one-third grown, hanging in a crevice in the site above described, when touched and lightly pressed down, slowly moved its legs and began to struggle back to its perch. The thermometer ranged from 20° to 25° above zero; on the day before the range was from 21° at 7 A. M. to 28° at 11 A. M. During the six weeks over which these observations extended the temperature was unusually low for this vicinity; for a great part of the time the thermometer stood below zero. The month of March following was unusually severe, the thermometer frequently reaching winter temperature. On the 1st of April, however, the above named spiders and others of a younger brood were in their webs, hale and active, having been drawn out by the first soft days of spring. It would seem, therefore, first, that the hibernation of spiders, of this species at least, is not accompanied with a great degree of torpidity; second, that they preserve their activity and spinning habit while exposed to cold ranging from freezing point to zero (Fahrenheit); third, that after long and severe exposure the recovery of complete activity, when brought into a warm temperature, is very rapid, almost immediate; and, fourth, that on the return of spring, even after a prolonged and severe winter, they at once resume the habits of their kind. The above experiments were made upon Theridioids, but I have made like trials with other species, as Epeira strix, Dictyna philoteichous, and Eurypelma hentzii, and the results vary in no essential particular.

Conclusions.

In all the above specimens the abdomens were full, indicating perfect health. Other spiders hung upon their webs with shriveled abdomens, quite dead, among them one of my specimens, a male who died during the course of observations. A Pholcus phalangioides hung thus dried up, holding with a death grip to her web by the two fore pairs of legs, which supported the cephalothorax in a position parallel to the plane of the horizon, while the long abdomen hung down at right angles thereto, and the third and fourth pairs of legs were drooped downward and backward. I could only conjecture that this and other spiders perished by the cold. The living individuals were all characterized by the plump abdomen, as though there had been little or no absorption of tissues for nourishment of life. There appeared to be no growth during hibernation.

V.

Many spiders have the habit, which belongs to certain insects and prevails even among the vertebrates, of feigning death. This habit, which is common among many species of spiders, appears to be particularly developed in the Orbweavers. One who touches an Orbweaver when hanging upon its web will often be surprised to see it suddenly cast itself from the snare, or appear to drop from it, as though shot off by some unseen force. Unless he understands the nature of the creature, he will be utterly at a loss to know what has become of it. In truth, it has simply dropped upon the ground by a long thread which had been instantaneously emitted, and had sustained the aranead in its remarkable exit, so that its fall was not only harmless but its return to the web assured. If the creature be now examined it will be found motionless. Its legs are drawn up around the body, and to the inexperienced eye it has the external semblance of death. In this condition it may be handled, it may be turned over, it may be picked up, and, for a little while at least, will retain its death like appearance.

Death Feigning.

It has been conjectured that this behavior is simply the result of fear, and is largely beyond the volition of the spider. It is a case, in other words, of what has been called kataplexy, or fear paralysis. It is, perhaps, difficult to disprove this theory, but I can by no means accept it. To me it seems a case of genuine "'possuming," if I may use a term which was commonly applied in the West, during my boyhood, to characterize all shamming or feigning among our associates.

Dr. Preyer, of Jena, has published his experiments on animals while under the influence of sudden fright,[1] the general trend of which is to show that unconsciousness is the resulting state. I do not know what value these experiments may have with experts in that general field of research, but I cannot accept the conclusion as to spiders. Mr. Campbell, however, appears to favor the theory.[2] Examples will occur to every one, of wild animals met in walks through the woods or fields, suddenly pausing as though the first appearance of a supposed enemy had shocked them into inaction. A child falls, and, though not hurt, loses himself for a few seconds. When regaining consciousness he bursts out into a loud roar. Many moths never attempt to fly when touched, and the white ermine, the satin, the swallow tail, and the male ghost moth will fall as if paralyzed when a net is swept under them at night while on the wing. The clouded yellow butterfly will drop as if lifeless when closely pursued. Many species of beetles are inimitable death feigners, as most boys know who have any knowledge of field life.

Preyer's Kataplexy.

[1] Samlung physiologischer Abhandlungen, Zweite Reihe, Erster Heft, 1878.

[2] Observations on Spiders, page 46.

But it is needless to multiply examples; let us turn to the animals with which we are here chiefly concerned.

I have frequently watched spiders in this condition, to determine the point in question, and their behavior always impressed me as being a genuine feigning of death, and therefore was entirely within their volition. The evidence is of such an indefinite nature that one can hardly venture to give it visible expression, but my conviction is none the less decided. I may say, however, that my observations indicate that the spiders remained in this condition as long as there seemed to be any threatened danger; now and again the legs would be relaxed slightly, as though the creature were about getting ready to resume its normal condition, but at the slightest alarm withheld its purpose and relapsed into rigidity. The slight unclasping of the legs, the faint quivering indications of a purpose to come to life, and then the instant suppression of the purpose were so many evidences that the power of volition was retained, and that the aranead might have at once recovered if it had been disposed to do so.

FIG. 367. Dorsal view of Labyrinth spider in act of death feigning.

Not Fear Paralysis, but Voluntary.

Again, I think that I have never noticed anything like that gradual emergence from the kataplectic condition which one would naturally expect if the act were not a voluntary one. On the contrary, the spider invariably recovered, immediately sprang upon its legs, and hoisted itself to its snare, or ran vigorously away among the grasses.

Two positions of the Labyrinth spider while in the act of death feigning are here presented, from a number of sketches made from Nature. Fig. 367 represents her from a front view, leaning slightly upon one side. The two fore legs on the further side are doubled under the face, and the feet may be seen projecting on the opposite side; that is, nearest the observer. The other pair of fore legs are doubled under the side, the feet almost touching the third and fourth legs, which are bent in a position quite like that commonly assumed when the spider is sitting at her natural rest. The whole attitude appears to the familiar observer entirely different from any posture during death, and this may perhaps be seen by comparing these drawings with the death fashions shown in the first pages of this chapter.

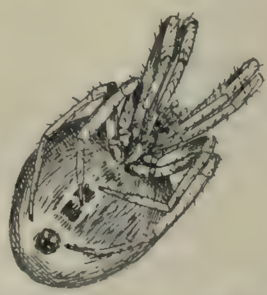


FIG. 368. Ventral view of Labyrinth spider while death feigning.

The second position is shown at Fig. 368, giving a view of the same spider from the lower part of her body while resting upon her back. The fore legs are all bent and doubled over around the mouth parts, the feet extending almost to the lower end of the sternum.

The third and fourth pairs of legs are folded in an easy position upon the venter. Applying a magnifying lens to these legs, one can see that they are connected by threads, which are attached to the spinnerets in the ordinary way, showing that the aranead is by no means unconscious of and indifferent to her usual methods of escape.

I give three other drawings which present in natural size three positions assumed by Epeira trifolium while death feigning. Two of these (Figs. 369 and 370) represent her lying upon her back with her claws doubled up in the manner previously described of the Labyrinth spider, and showing the same readiness to immediately relax the limbs and assume the ordinary position. The third drawing (Fig. 371) shows the spinnerets and two fourth pairs of legs holding on to the apex of little pyramids of threads which had been instantly thrown out just as the spider passed into its death feigning condition. One third leg may also be noticed, reaching downward to the spinnerets, and holding on to a line which had been outspun at the same time.

Trifolium's Attitudes.

This action in itself seemed to me sufficient indication that the spider retained entire control of her faculties. Instead of falling at once into

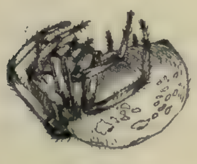


FIG. 369.

FIG. 370.

FIG. 371.

Death feigning attitudes of the Shamrock spider.

fright paralysis without any preparatory efforts at protecting herself, she secured herself by her spinningwork anchorages from being carried away without her knowledge, and gave herself the means of recovery to natural position. Of course the period of time between this act of self protection and the assuming of the death feigning attitude could scarcely be calculated; yet the whole behavior showed that after the act which is supposed to have induced kataplexy, and between it and the kataplectic attitude, there was this deliberate effort to secure herself in the ordinary and natural manner. This was so manifest that, on observing it time and again, I was extremely amused by the manifest stage effects of the aranead actress, and could not help comparing it with the alleged method of certain women addicted to voluntary "fainting," who are said deliberately to pick out the most agreeable spot on which to fall, and to adjust their limbs and drapery in the most graceful and convenient manner before the faint! In the case of the Shamrock spider also, as with Labyrinthea, the recovery from the death feigning attitude into natural posture showed, in the transition, the marks

of entire self possession, as though consciousness had never for a moment been lost.

My conclusions in this matter are substantially supported by the experiments made by the Peckhams, which are recorded quite at length.[1]

Peckhams' Studies.

These naturalists made two hundred and ten experiments on this subject upon spiders taken from fifteen different genera, and their resulting conclusion is that no spider under their observation ever fell into a kataplectic condition. A few of their experiments may be quoted, with the remark that, as far as they cover the species experimented upon by myself, they are confirmatory of my results.

One of the best death feigners is Epeira bombicinaria, a species identical with Epeira parvula. A pretty little female was softly touched as she hung in her web. She fell two feet, and then swung to a neighboring branch, where she crouched motionless for three minutes. Being again gently touched, she fell to the ground with her legs outstretched, and then, quickly drawing them in, remained clinging, in a very inconspicuous heap, to a blade of grass. Here she stayed motionless for one hour, when she was placed in a bottle, carried into the house, and, still keeping perfectly quiet, was shaken out on a table. After two hours she was pushed by the end of a brass rod. Then her legs were lifted one by one with a needle. She seemed so lifeless that they began to wonder if they had been watching a dead spider after all. They finally touched her with the point of a needle, but at the first suggestion of a prick she ran rapidly away. She was knocked over as she ran and remained motionless just as she fell, resting on the cephalothorax with all the legs drawn closely in, excepting one which was slightly extended. She did not look like a live spider, nor like a dead one, nor like anything except a bit of bark or lump of dirt. She laid thus without a perceptible quiver for more than two hours and a half, and then suddenly ran away. She was reduced to quiet several times after this, but was less patient and endured no more handling. She did not usually lie still just as she fell, but deliberately gathered up her legs in such a way that they were indistinguishable from each other and from her body.

Parvula's Shamming.

Another example of remarkable death feigning was a large female Epeira infumata. She was put into a tumbler and left until the following morning, when one of the Peckhams, on looking at her, exclaimed that she was dead! Her legs were drawn up and bent, and she looked stiff and dry. She was handed from one to another of those present. Her demise was duly regretted, and her wonderful protective coloring was remarked upon. She was then put back into the tumbler. An hour later, much to their astonishment, she was found moving about, alive and well. As they were experimenting

Infumata's Feigning.

[1] Journal of Morphology, Vol. I., No. 2, 1887, page 408, sq.

at this time upon the color sense, Infumata was placed in one of the boxes of colored glass described in a preceding chapter, and, at intervals of one hour during the day, was moved from the section in which she had settled to another. Every time this removal was made she fell stiffly on her side, drawing her legs in and remaining thus for about three minutes. In experiments with her afterwards, the Peckhams found that, when knocked about on a table, she would stay in the position in which she fell, although this was often an uncomfortable one. She showed no sign of life when rolled about, but jumped up at the least prick of a needle. She never remained quiet for more than twenty-seven minutes, and never absolutely motionless for so long a time as this, there being slight quivering movements of the legs and palps at intervals of three or four minutes.[1]

A Spider Stoic.

The Peckhams had found no spider that would endure bad treatment without showing signs of life, until they experimented on the Insular spider. When put on a table, Insularis acted much as Infumata had done, but had no such rigid, lifeless appearance. When she was knocked or touched with the point of a needle, there was a convulsive twitch of the legs, though she seemed to be trying to keep quiet. The first time she was pricked so as to puncture the skin she remained motionless. But at the second puncture she ran. Afterwards, from both males and females of this species, the observers obtained similar results, once finding an individual that did not run until the skin had been punctured five times. When the needle entered the skin, there was usually a twitching of the legs, which seemed to show that sensation was present. Outside of this species the Peckhams found no spider that would endure a puncture of the skin without running away, and they rarely found one that would keep quiet while being handled.[2]

Darwin's View.

Such a remarkable instinct as that of death feigning did not, of course, escape the observation of such an incomparable naturalist as Darwin. He tells us[3] that he carefully noted the simulated positions of seventeen different kinds of insects, including among them a spider. These belonged to the most distinct genera, both poor and first rate shammers. He afterwards procured naturally dead specimens of some of these insects, and others he killed with camphor by an easy, slow death. The result was that in no one instance was the attitude exactly the same, and in several instances the attitude of the feigners and the really dead were as unlike as they possibly could be.

The Peckhams in the course of their experiments received the impression that the habit of keeping still after dropping must not only help the spider to avoid detection, but must also make it more certain of finding

[1] Ibid., page 410. [2] Ibid., page 410.

[3] Essay on Instinct, Appendix to Mental Evolution of Animals, by G. J. Romanes, page 363.

its way home after the danger is over. There would thus be a double advantage in absolute quiet.[1] It will be remembered that as a spider drops from a web or other roosting place it spins a line, which forms a straight path backward from the starting point to the stopping point. It can thus easily return to its snare or roost by means of this trapline, provided it remains quiet at the first point of stoppage. But, if the spider moves, its trapline becomes a dragline, the end of which adheres to the first point of stoppage; after another short interval this is attached to another point, and so on, to another and another as the spider moves.

Origin of Death Feigning.

Now, the Peckhams think that this last action tends to confuse a spider, and make its path homeward indirect. In this view they seem to think themselves justified by some experiments made with the Labyrinth spider, and to some extent I have no doubt they are correct. But I hardly agree with them in the importance which they give to this fact as emphasizing the theory that it would be of great value to the spider to remain quiet at the point first reached after dropping from its web. It seems to me that it is not difficult for a spider to return by its dragline to the point where it might reach its dropline, unless, indeed, it should wander far into the mazes of leaves, or by any misfortune its dragline should be broken and thus lose its trail. The truth or falsity of this view is interesting, because of the opinion of the Peckhams that the possibility of losing itself makes it much more to the interest of the spider to remain quiet at the place it first reached when dropping from its snare; and, further, that this usefulness of the quiet attitude may have been the starting point from which, by natural selection or otherwise, the death feigning habit may have been developed.

The matter seems to me to require further test before one can positively decide. At all events, the Peckhams accept Darwin's explanation of the habit of lying motionless as the result of natural selection, and that it has been acquired by different species in different degrees according to its usefulness in their various modes of life. Thus we find it in its greatest development among the comparatively sluggish Epeirids, whereas it is badly developed or lacking in the running or jumping spiders which are able, as any one who has pursued them will testify, to move with astonishing rapidity.[2]

In connection with this subject the question naturally arises as to whether insects show any sign of fear in the presence of spiders. Campbell only once observed an attitude in a fly which might be taken as coincident with fright paralysis. The fly was about one and a half inch from Tegenaria domestica, was busy cleaning itself, when suddenly it stood motionless in the very act of rubbing its claws

Fearless Flies.

[1] Op. cit., page 413. [2] Ibid., page 417.

together, until it was shortly afterward seized.[1] Mr. Belt states that he has seen cockroaches retreat in full haste when they had unexpectedly approached a large spider.[2] I have already, when speaking of warning coloration (page 340), expressed my lack of faith in the supposed paralyzing influence of spider enemies, at least on insects. Of a vast number of insects, especially flies and grasshoppers, fed to spiders of various species in captivity, I have not noted and do not remember a single individual that showed the least evidence of fear or disturbance of any sort. Even when placed in the box with the giant of the order, the huge Tarantula, insects appeared unaffected.[3]

These observations of the apparent fearlessness of flies in the presence of their natural enemy is confirmed by Moggridge.[4] He habitually fed his captive spiders with common house flies, and remarks that it was curious to see how entirely the latter were wanting in any instinctive fear of even the largest spiders. They would creep between a spider's legs, causing it to start as if electrified; and frequently it was not until a fly, after repeating this annoyance several times, actually walked up to and almost touched the fangs of the spider that it was punished. Certainly such facts indicate a lack of anything like fear paralysis or consciousness of danger on the part of flies in the presence of spiders.

Feigned Death Among Men.

There is no doubt that some higher animals possess the power of voluntarily assuming the external form of death. Numbers of well authenticated examples of this power are recorded among men. Dr. S. Weir Mitchell related to me an example which occurred under his father's observation many years ago in a Chinese port. A Chinaman came on board for purposes of barter, and made himself so disagreeable by his importunity that he was finally ordered to be put off the vessel into his boat. He resisted the order, and as it was being enforced fell down apparently dead. All efforts to restore him were fruitless. He was taken ashore amid great lamentations on the part of his countrymen and friends, and of course damages were assessed upon the shipmen. The officers refused to do anything unless the body were brought on board, and it was accordingly carried to the ship in a boat, and laid down upon the deck, still maintaining every appearance of actual death. The officers, whose suspicions were thoroughly aroused by this time, still refused to pay the demanded recompense until they had made some last, severe, and satisfactory test that the man was actually dead. As they were about to proceed with this test the supposed dead man rose to his feet, and, with grumbling and maledictions, which were echoed by his discomfited associates, descended to the boat and pulled ashore. The self hypnotism in this case was so decided that the shrewd American observers were for a long time thoroughly deceived.

[1] Observations, page 47.
[2] The Naturalist in Nicaragua, page 110.
[3] See also Vol. I., page 256.
[4] Trapdoor Spiders, page 246.

Well authenticated cases of self hypnotism, far more striking than these, are recorded as occurring in India. One was seen by Captain Osborn—a fakir who buried himself alive at the court of Runjeet Singh for six weeks. Another was observed by Sir C. E. Trevelyan, of a fakir who buried himself for ten days.[1] In these cases transition from the normal condition of life to the appearance of death was gradual, but was undoubtedly voluntary.

Self Hypnotism.

Most persons are acquainted with the paralyzing influence of fear, or the sudden excitation of emotions of any kind, whether sorrowful or joyful, upon the human mind. The most quick witted are subject thereto, and persons with more sluggish intellect are even more affected thereby; but the symptoms of this action, so far as I have been able to study them in human subjects, are wholly different from those which I have observed in the case of spiders. Of course, the vast difference of grade between the two creatures in the order of organization and intellect may be considered quite sufficient reason for this; yet one might be excused for expecting that there would at least be so much of analogy between the two as to form a basis for judgment. In the absence of such analogy I must adhere to my opinion that the behavior of the spider is a genuine case of voluntary death feigning. One who has observed the process will come to the conclusion that Arachne's histrionic abilities are of no mean grade.

Symptoms of Fear Paralysis.

The purpose of this habit is undoubtedly protective. I have often been deprived of coveted specimens by their sudden exit from the web just as I was about to seize them, and, although I knew thoroughly their habit, and just where to look for them in the grass beneath the snare, I have frequently been disappointed in my search. One may, therefore, well conceive the amazement, or whatever emotion there may be akin to that within the minds of lower animals, that seizes upon the raiding bird or wasp which darts, with seeming good aim, at the plump prize in the centre of the snare, and finds beak and claws grasping empty air or seizing only strands of the still quivering web. One might carry the fancy still further, and imagine how the spider from its grassy shelter must laugh, or go through whatever intellectual process may be analogous to that action in the spider brain, when it thinks of the discomfiture of its enemy as it flies empty away!

Purpose of the Habit.

When we come to think of the origin of this habit, perhaps, we may be justified in giving some place to the theory of fright paralysis.[2] Possibly the success in escaping hostile attacks experienced by some remote

[1] See observations on Trance or Human Hibernation, by James Baird, M. R., C. S. E., C. M. W. S., London, 1850.

[2] Romanes, Mental Evolution in Animals, page 308.

spider ancestor may have been a feeble beginning of the habit, which gradually was developed into the fixed characters which we now observe. A supposition of this sort, it is true, has no facts to support it, but is in accordance with prevailing ideas as to the evolution of many, if not all the interesting traits in animal behavior.

Origin of the Habit.

In this connection one may perhaps allude to the remarkable semblance of death into which the spider involuntarily falls when pricked with the sting of the digger wasp. I have referred to this in the preceding chapter, and quote here in confirmation a remark of Mr. Fabre, descriptive of the condition of Lycosa narbonensis of France, after being paralyzed by Pompilus annulatus. The spider is immobile, lithe as when living, without the slightest trace of a wound. It is life, in fact, minus movement. Viewed from a distance, the tip of the feet tremble a little; and that is all. One specimen disentombed from a wasp's burrow was placed in a box, where it kept fresh, preserving the flexibility of life from the 2d of August to the 20th of September, a space of seven weeks.[1] With spiders in such condition there is really no appearance of death. They are unconscious though living, and therefore make no sham of being dead.

Death Paralysis.

[1] J. H. Fabre, Nouveraux Souveniers Entomologiques. Studies upon the Instinct and Habits of Insects, page 210, 1882.

PART VI.—FOSSIL SPIDERS.

CHAPTER XV.

ANCESTRAL SPIDERS AND THEIR HABITS.

THE interest which attaches to the spider fauna of the present era naturally reaches backward to those of geologic time. I therefore undertake a sketch of the fossil remains of spiders, with particular view to gaining, if possible, some key to ancestral habits. The material for our review is not abundant, but fortunately we have sufficient data to give our inquiry an intelligent interest.

I.

Fossil Spiders.

According to Scudder,[1] one hundred and ninety species of spiders have been discovered from the Tertiary deposits of Europe. Mr. Scudder describes thirty-two from America in his work on the Tertiary Insects, of which fourteen are Orbweavers, being forty-four per cent of the whole number of species. The proportion of known fossil Orbweavers in America is much greater than in Europe.

A notable addition to our knowledge of the spiders of Tertiary Europe has been made by Gourret in a paper on those of Aix, in which, among others, eighteen species are described, including two of Erisoidæ, two of Lycosoidæ, one of Theraphosoidæ, one of Dysderides, two species of Hersillioidæ, two species of Erocteroidæ, one Enyoidæ, none of which families had been before found in European rocks, and the last two named not even in amber.[2]

Of the fossil spiders of Europe, one hundred and sixty-eight are described from enclosures within amber, forty-one only from the rocks. It will thus be seen that while Europe is much richer in spiders when the amber fossils are included, America has yielded more than three-fourths as many from the Tertiary rocks and one from the Carboniferous.

The fossil spiders found in America are distributed as follows: Saltigrades, three species of Attids; Laterigrades, three species of Thomisids. Tubitelariæ: Dysderides, one species; Drassides, five species; Agalenades, two species. Retitelariæ: Theridides, four species. Orbitelariæ: Epeirids, fourteen species.[3] Arthrolycosa antiqua is probably a Territelarian.

[1] Tertiary Insects of North America, pages 48–90, U. S. Geol. Survey of the Territories, Vol. XIII. [2] Ibid., page 52. [3] Ibid., page 49.

Fossil Sites.

The discovery of fossil spiders on this continent is confined chiefly to a single point, Florissant, Colorado, although Green River, Wyoming, and Quesnel, British Columbia, have contributed some specimens. The remains occur in a series of lacustrine deposits formed within an ancient lake basin which lies in the valley of the present South Fork of Twin Creek, and of the upper half of the same after the South Fork has joined it. This ancient Florissant Lake basin lies among a series of low wooded hills and ravines marked by an irregular L-shaped grassy meadow. At the period of the Oligocene this elevated lake must have been a beautiful shallow sheet of fresh water. It was hemmed in on all sides by granitic hills, whose wooded slopes came to the water's edge, sometimes, especially on the wooded sides, rising abruptly, at others gradually sloping, so that reeds and flags grew in the shallow waters by the shore. The waters of the lake penetrated in deep inlets between the hills, giving it a varied and tortuous outline. Steep promontories projected abruptly into the lake from either side, dividing it into a chain of three or four unequal and irregular ponds united by a narrow channel to a larger and less indented sheet, dotted with numerous long and narrow wooded islets just rising above the surface. Along these wooded islands and indented shores, a most congenial habitat, the spiders of the Tertiary had their homes. The Orbweavers and other Sedentary groups hung their snares among the branches of young hickories, oaks, birches, poplars, willows, elms, wild roses, sumac, alder, ferns, catalpa, and bignonia, precisely as in our own woods; or spread them among the blossoms of water lilies and clumps of grasses, reeds, and iris that thrust their stalks out of the shallow waters, as one may see to-day in the ponds of New Jersey and the lagoons of the South.[1]

Cause of Entombment.

The promontories projecting into this lake bed on either side are formed of trachite or other volcanic lavas; masses of the same occur at many different points along the ancient shore. They seem to be confined to the edges, for the most part, but some of the mesas, or ancient islands, have trachite flows over them, and their slopes covered with quantities of vesicular scoriæ. We have thus pointed out the principal cause of the fossil strata whose exploration has uncovered for us these pages in the life of the spiders of the Tertiary. The shales of the lake in which the myriad of plants and insects are entombed are wholly composed of volcanic ash and sand, which lie fifteen feet thick or more in alternating layers of coarser and finer material.[2]

[1] Lesquereux identifies these as among the plants found in the fossil yielding strata. The genera are identical with the corresponding existing plants. U. S. Geolog. Surv. Terr., Vol. VII., Tertiary Flora, 1878. Insects and spiders are usually found in the same shales that yield the plants.

[2] Paleontology of Florissant, S. H. Scudder.

These insect bearing strata, as described by Dr. M. E. Wadsworth,[1] are brownish and grayish brown shales, being simply the finer material of the tufas laid down in laminæ of varying thickness and coarseness. This volcanic material has evidently been worked over by water; so far, however, as can be judged by microscopic examination, when the water commenced its work the material was in loose, unconsolidated deposits. That it was thrown out as an ash, or rather deposited as a moya or mud flow near its present location, is the most probable supposition. The deposition appears to have been gentle but comparatively rapid, for there is no sign of violence or even of such decomposition as one should expect in slow deposition; and showers of ashes falling on still water or a lake, acting on an unconsolidated tufa bank, answer best the conditions called for here.

II.

Manner of Entombment.

According to Lesquereux the numerous leaves of some of the species of plants are not crumpled, folded, or rolled as if driven by currents, but flat as if they had been imbedded in the muddy surface of the bottom when falling from trees or shrubs along the border of the lake. As leaves, seeds, and other parts of a plant are always intermingled with the fossil insects and araneads, we may conclude that their entombment resulted from dropping along with the leaves into the water. It will be remembered that many spiders make their snares permanently among leaves, or within the inner surfaces of leaves, so that, when they are stripped from their stems by violence or natural decay, they must often drift from the banks into streams, and if overhanging the water drop directly therein. Others, like our Insular and Shamrock spiders, dwell within nests of curled leaves, and these would meet the same fate under like circumstances. It is not now uncommon to see such nests overhanging the borders of streams or woven among the foliage of plants in the immediate vicinity. Supposing, as we have a right to do, the same habits prevailing in the Oligocene period as the present, all these leaf dwelling species would have been exposed to submergence in the ancient Florissant Lake, and, being imbedded in the mud, some of them, at least, might be preserved.

Lesquereux further believes that the deposition of the vegetable materials took place in the springtime and that the lake gradually dried during summer. He bases this inference on the complete absence of hard fruits, together with the presence of flowers, of unripe carpels of elm and maple, and of well preserved branches of taxodium, which, in the living species, are mostly detached and thrown upon the ground in wintertime or early spring. If this were so, there would have been far fewer mature spiders at that season, and the very young would be less likely to fossilize.

[1] Scudder, Paleon. Floriss.

Scudder thinks that the structure of the rocks indicates a quiet deposition of the materials in an unruffled lake through long periods, interrupted at intervals by the influx of new lava flows, or the burying of the bottom sediments beneath heavy showers of volcanic ashes.[1] That many insects and spiders were beaten down by these showers, destroyed, and buried, is at least probable. Certainly we shall not go far astray in picturing such an exigency in the life history of the disentombed fossil spiders in our possession. Thus the story of Pompeii was enacted among the aranead inhabitants of this upland lake shore in the distant Tertiary.

Volcanic Showers.

In this case, every season must have added contributions to the imbedded forms. After the final act of maternity female spiders soon die. They may often be found, dried up, quite dead, hanging to grass or foliage, whence they drop off with the leaves. It was not different with the fossils of Lake Florissant; they dropped to the ground and were carried into the water, or dropped directly into the lake, and sank into the muddy sediment, and were buried under the volcanic mud flow.

By a process somewhat similar the spiders of the Swiss Miocene appear to have been entombed, these soft animals being preserved only in the calcareous marl of the lower Oeningen quarry. Twenty-eight species have been uncovered, of which one, Epeira molassica Heer, is an Orbweaver.[2] These fossils are, for the most part, small, delicate creatures, belonging, with one exception, to genera widely represented among living fauna. Eleven species are figured but not described by Heer, whose figures are repeated by Heywood.

Oeningen Spiders.

Of the insects which fell into the water of the ancient Lake Oeningen, only those have been preserved which were quickly covered by the mud, and thus saved from destruction. Aquatic insects are numerous, and are found in all stages as larvæ, pupæ, and imagines. Many were so rapidly enveloped by the fine calcareous deposit that they have not merely produced an impression in it, but even the organic substance has been preserved. By this rapid covering the softest midgets are so admirably preserved that, under the microscope, the hairs of their legs and wings can be recognized, and the color of the land bugs can still be ascertained. Thus, in Europe as in America, we can picture the local conditions under which the ancient spiders lived as not very different from some of our littoral Atlantic lakes, as Deal Lake, for example, or those of Florida, and the lagoons and bayous of the Southwest Mississippi. The general aspect of the landscape; the forms and foliage of plants; the flowers and the insects that visited them, like the spiders that made them their prey, must have given a familiar face to the scenery.

[1] Paleon. Florissant, page 298.

[2] The Primeval World of Switzerland. By Professor Heer. Heywood's English translation, Vol. II., page 10, 1876.

III.

The climatic conditions under which the Florissant spiders lived and died are established by a testimony which is quite accordant, both from the fossil flora and fauna. According to Lesquereux, the plants indicate a climate like that of the northern shores of the Gulf of Mexico at the present epoch, and have a general aspect which recalls that of the vegetation of uplands or valleys of mountains. The fishes, according to Professor Cope (quoted by Scudder), indicate a climate like that at present found in latitude thirty-five degrees in the United States.

Climatic Conditions.

Professor Scudder thinks that the insects from their general ensemble prove a somewhat warmer climate. He refers especially to the presence of a great number of white ants imbedded in the shales, a testimony that is confirmed by a study of other insects, which are found to be largely tropical or subtropical in their nature.[1] In a subsequent brief and interesting review of the Florissant spiders, and comparison with those from the European beds,[2] Mr. Scudder repeats this opinion. He considers that the present distribution of the allies of the fossil spiders points to a climate like that of the middle zone of our Southern States, or the two shores of the Mediterranean in Europe. However, of the genera which he cites in proof of this, only one, Nephila, seems to me in point. This spider is undoubtedly tropical. I have a number of species from Africa, Zululand, Madagascar, Liberia, etc., where they have an enormous development.

Our Gulf States have one species, Nephila plumipes, which is abundant in many parts thereof, and is even more characteristic of the spider fauna of Central America and the West Indies. As it has never yet been found in the United States outside the southern belt of the Southern States, the presence of a closely related species in the Florissant shales would seem to be conclusive as to the nature of the climate during the period at which their fossils were imbedded. The specimen published by Professor Scudder, which I reproduce (Fig. 372), is well enough preserved to prevent any doubt as to its generic identity.

Fossil Nephila.

According to Scudder[3] it is a much smaller species than Nephila plumipes Koch, if the fossil be fully grown, and differs from it in some striking points. The eyes differ considerably, although the position of only two of those of the fossil species is known. The corselet is squarer in the fossil, and per contra the abdomen is oval and not quadrate, while the tarsi are unusually long in proportion to the whole leg. The tufts of hairs occur only on the extremity of the tibia. I have not seen the fossil, but judging

[1] Paleontology of Florissant, page 299.

[2] Fossil Spiders, Harvard University Bulletin, No. 21, page 303; see also Tertiary Insects, page 51.

[3] Tertiary Insects of North America, page 90, pl. xi., Fig. 12.

from its general aspect, as displayed in the figure alone, I would suspect it to be a young female Nephila plumipes. I have specimens of a species collected by Mr. C. H. Townsend, at Swan Island, Caribbean Sea, which in size and general appearance more closely resembles Scudder's description of Pennatipes than the modern Plumipes. The femoral brush is lacking in these specimens, as it is in Scudder's fossil (although there they may have simply been worn away), and the shape of the abdomen is also cylindrical, as with Nephila pennatipes, instead of being quadrate as with our species. We have thus a living Orbweaver which, as far as it is possible to judge, differs little from this ancient aranead.

Climate. On the presence of this fossil species alone I would assimilate the climate of the ancient Florissant Lake to that of a region even further south than that assigned by Mr. Scudder.

FIG. 372. The fossil spider Nephila pennatipes. (After Scudder.)

Scudder[1] describes a fossil Tetragnatha, T. tertiaria, which he thinks does not appear to have any special affinity with the American species with which he has been able to compare it, being stouter bodied than they. His conjecture, however, is hardly a true one, that the presence of this genus in the neighborhood of the lake deposits of Florissant indicates a warmer climate than the present. Tetragnatha, in several species, has a range over the whole of the United States, and I have fine specimens from as far north as the borders of Alaska. They are extremely numerous in such a climate as Philadelphia, for example, where we have the European species Tetragnatha extensa; and along the margins of our ponds and waters are seen immense numbers of large examples of the Stilt spider of Hentz, Tetragnatha grallator, which is probably identical with Tetragnatha elongata of Walckenaer.

A study of the spider fauna also justifies the inference that the climate of the Tertiary period in Europe was essentially the same as that of Florissant. This is especially strengthened by a view of the recovered insect forms of the two continents.[2] Of the insects in amber Mr. Hope

[1] Ter. Ins. N. A., page 77.

[2] Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France. Par M. Oustalet, pages 6 and 38. Bibliothèque de l'Ecole des Hautes Études, 1874.

states that they are extra-European, many belonging to tropical and temperate climes. Dr. G. Mayr thinks the amber ants have few relations with ants of tropical Africa and America.

IV.

Europe and America.

It may be remarked, in this connection, that a comparison of the fossil spiders of Europe with those of Florissant shows, on the whole, a general correspondence between the two fauna. The same families are represented in the stratified deposits of Europe and America; and the correspondence holds good, to a considerable extent, as to the amber species. Among Orbweavers this correspondence is not so close, but obtains if we confine the comparison to families, and is true in a measure of the genus Epeira and its near allies. Of the Oeningen spiders one is an Epeira. From the Brown-coal the Gea of Von Heyden[1] is an Epeira also, according to Thorell.[2] Of the Amber species,[3] Grœa Thor. (Gea Koch and Berendt), and Antopia (Menge) are near Epeira; Siga (Menge) is near Zilla. All of these belong with the family Epeirinæ. Androgeus (Koch and Ber.) alone probably belongs to another family, the Uloborinæ. Scudder divides the Orbweaving species of Florissánt among four genera, Epeira, Tethneus (new), Nephila, and Tetragnatha, all Epeirinæ. Thus all the Orbweavers in both continents, with the exception of Androgeus (if Androgeus be, indeed, an Orbweaver), belong to the same family Epeirinæ, and most of them to Epeira and closely related genera.

FIG. 373. FIG. 374.
Fossil spiders from the amber. (After Berendt.[4])
FIG. 372. Gea epeiroidea. FIG. 373. Androgeus militaris; male.

Fossil and Existing Fauna.

The above comparison also shows a close resemblance between existing spider fauna and that of the Tertiary both of Europe and America. For example, the Orbweaving genera Epeira, Zilla, Tetragnatha, and Nephila are now common to both hemispheres, are all found in the United States, and the first three abundant. We should consider, moreover, how closely related the remaining fossil genera are to these and other existing ones. Tethneus, Gea, Grœa, and Antopia (Epeira), Siga (Zilla), and Androgeus (Uloborus) can, in this view, scarcely be said with confidence to differ from existing Orbweaving genera. The

[1] Paleontographica, Beitrage zur Naturgeschichte der Vorwelt, Band VIII. "Fossile Insekten aus der Rheinischen Braun-kõhle," von C. von Heyden. Taf. I., Fig. 11, page 2. Gea krantzi Heyd. Fundort: Rott, Sammlung Krantz. [2] European Spiders, page 223.
[3] Ibid. [4] Op. cit. below, Tab. III., Figs. 12, 17.

fact may be readily seen by comparing Berendt's numerous figures of the well preserved amber spiders with examples from corresponding genera. (See Fig. 373, compared with Figs. 376 and 377, and the full page cut further on.)

The Florissant fossils are of course not so well preserved, but some of the specimens retain their characteristics with sufficient distinctness to compel the same conclusion. Scudder's figures, as they are displayed upon his plate, might well stand for good drawings of a miscellaneous collection of damaged specimens of our living spiders. Compare his figure of the fossil Orbweaver Epeira meekii, for example (Fig. 375), with our familiar Epeira strix (Fig. 376) or Epeira insularis (Fig. 377).

FIG. 375.

FIG. 376.

FIG. 377.

FIG. 375. Fossil spider of Florissant, Epeira meekii. (After Scudder.) FIG. 376. Existing spider Epeira strix; male. FIG. 377. Existing spider Epeira insularis; male.

Oldest Known Spider Fossil.

Turning to the oldest known fossil aranead, Protolycosa anthrocophila Römer, we are brought face to face with a species closely related to existing fauna. (Fig. 378.) Protolycosa belongs to the Carboniferous, being found in the argillaceous slate of Kattowitz, upper Silesia.[1] Fig. 379 is an enlarged drawing, and Fig. 380 is an outline restoration by the author. Römer placed the fossil near the genus Lycosa of the Citigrades, which rank among the highest of the araneads. Thorell, on the ground of the extremely coarse and short, strong legs and palps, assigns it to the Territelariæ, which puts it within a closely related group, in which we have found the largest existing spiders, Theraphosoidæ, the Tarantulas, and such also as possess the highest mechanical instincts, as Trapdoor spiders. The first apparition of the spider is therefore by no means that of a low example, but one rather which presents a plenitude of faunal characteristics, and gives the possibility of high industrial skill.

Moreover, Protolycosa is nearly related to a living species. Thorell points out its marked resemblance to Schiodte's wonderful East India genus

[1] Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie, Jahrg. 1866, pages 136–143, Taf. III., Figs. 1–3.

Fig. 380.

Fig. 378.

Fig. 379.

The oldest fossil spider, Protolycosa anthrocophila. (After Römer.)

Fig. 378. The spider in site. (Natural size.) Fig. 379. An enlarged drawing of the spider. Fig. 380. A restored figure.

Liphistius,[1] and for this reason assigns it to his own family of Liphistioidæ.[2]

Oldest American Spider.

Among the oldest fossil spiders, and probably the oldest in America, is Arthrolycosa antiqua, from the Coal measures of Illinois, described by Mr. Harger.[3] As the horizon in which this fossil was taken is synchronous with that of the argillaceous slate of upper Silesia in which Protolycosa was discovered, this American spider has the distinction of being one of the oldest as yet known to science. Its true determination is therefore a matter of great importance. The aranead has generally been recognized as a type of a new family, Arthrolycosidæ, as first established by Mr. Harger. Professor Scudder placed the family at the beginning of the order Anthracomarti. The supposed forcipulate character of the mandibles was considered sufficient evidence to overcome the otherwise general resemblance to the Territelariæ, but this characteristic now appears to be without sufficient warrant.

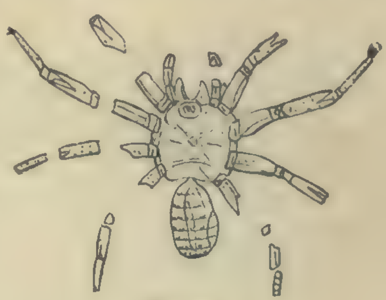


FIG. 381.

FIG. 382.

FIG. 381. Fossil spider Arthrolycosa antiqua. (After Beecher.) FIG. 382. Profile of the same, viewed from the front. (After Beecher.)

Arthrolycosa antiqua.

Professor Scudder[4] made a reëxamination of the type in 1884, and decided against the forcipulate character of the palps as described by Harger. More recently Prof. Charles E. Beecher has made a thorough study of the type specimen, after cleaning it and exposing the appendages by removal of the superincumbent matrix. After noting the differences which the study of the specimens under these conditions developed, Professor Beecher concluded that on account of these important differences it seems necessary to exclude the genus from the order Anthracomarti.[5] The marked resemblance between the ancient Avicularidæ and the fossil seemed to suggest that Arthrolycosa is entitled to a place in the suborder Tetrapneumones, among the Terri-

[1] "Om en afvigende Slaegt af Spindlernes Orden." J. C. Schiodte. Natur historisk Anden Raekes andet Bind Tidskrift, 1846–9, Bd. II., Rak. 2, page 617, sq. Thorell's reference is wrong, a typographical error doubtless, making pages 6–7 for 617. As I count, he also errs in the order of length of legs, which is 4, 3, 2, 1, instead of 4, 2, 3, 1. There is, however, but a fractional difference between third ($17\frac{23}{50}$ lin.) and second ($17\frac{7}{50}$), and this does not change the force of the inference. The species is Liphistius desultor; female. Habitat, Pinang Island.

[2] European Spiders, page 222.

[3] American Journal of Science, 1874, Vol. VII., pages 219–223.

[4] Proc. Amer. Acad. Arts and Sci., Vol. XX., 1884, page 15, "A Contribution to our Knowledge of Paleozoic Arachnida."

[5] Note on the Fossil Spider Arthrolycosa antiqua Harger, by Charles E. Beecher. Amer. Journ. of Science, Vol. XXXVIII., 1889, page 219.

telariæ. I insert a fac simile copy of the figure published by Professor Beecher (Fig. 381), representing a dorsal view of the fossil, and (Fig. 382) a bare outline when viewed directly in front. From the figure and profile it is seen that all the limbs of the spider are in nearly their natural position, having undergone but slight displacement and decay, while its perfection indicates that it is not a shed skin which is preserved, but that the actual animal was entombed. It throws an interesting side light upon the life habits of this creature, to learn that in the same concretion which contains the fossil are fragments of the broad leaves of a rush like plant which, as Professor Beecher thinks, probably furnished a float by which the spider was carried out from land, so that its remains are found mingled in the same bed with marine organisms.

In this connection I may call attention to another fossil spider which has been supposed also to belong to the Territelariæ. While visiting the British Museum of Natural History at South Kensington, London, in the summer of 1887, my attention was called to some fossil spiders by Dr. Henry Woodward, Keeper of the Geological Department. Among these I observed one which seemed new to science, and closely related to the genus Atypus. After my return to America, Dr. Woodward sent me casts both in wax and plaster, from which a description of the species was made, and the name Eoatypus woodwardii suggested.[1] The fossil is simply an impression in the shale, which, however, is tolerably well preserved, but exhibits few features necessary to classification. The eyes are not defined, and nothing but a little roughened elevation in the centre of the caput, which may or may not be an organic cast, gives any suggestion of the eye space. As far as it goes, this appears to follow the characteristics of Atypus and the Territelariæ generally. The appearance of the mandibles also suggests this relation, and the general facies of the fossil is to the same effect. The drawings have been made from a plaster cast, Fig. 383 representing the dorsal view, and Fig. 384 the same in outline, both magnified three times natural size.[2]

FIG. 383.

FIG. 384.

FIG. 383. Fossil spider Eoatypus woodwardii McCook. Dorsal view. ×3.
FIG. 384. Eoatypus woodwardii. Side view. ×3.

[1] Proc. Acad. Nat. Sci., Phila., 1888, page 200, for full description of the species.

[2] I hesitated much as to whether this fossil should be assigned to the Lycosidæ, the Attidæ, or to Atypinæ. On the whole, I decided, though not positively, as above, and on the above named grounds. It seemed impossible, in the absence of the characteristic eyes and long jointed superior spinners to relegate the species positively to the genus Atypus. Besides expressing the general facies of the fossil as above described, the generic value of the name Eoatypus consists largely in assigning the specimen rank as a fossil spider.

The horizon from which this fossil was obtained is the Eocene Tertiary, Garnet Bay, Isle of Wight. It is, therefore, probably somewhat older than most European and American aranead fossils.

According to Scudder, more than one-half the genera of known fossil spiders to which species have been referred have been described as new and peculiar to Tertiary times. These genera include about two-fifths of the species. Among the genera are some remarkable forms, such as Archea and Mizalia, each of which is considered by Thorell and others as representing distinct families.[1] Further on I reproduce Berendt's drawings of Archea paradoxa, to illustrate these peculiar forms.

FIG. 385.

FIG. 386.

FIGS. 385 and 386. Views of Palpipes priscus, a fossil crustacean larva. (After Von Meyer.)

Two genera only of the thirteen to which the American species are referred are described as new, and to them are referred seven of the thirty-two species. Other genera not before recognized in a fossil state, but here recorded from American strata, are Titanœca, Tetragnatha, and Nephila. To enter into details, seventy-one genera of spiders have been described from the Tertiaries, sixty-six from Europe, and thirteen by Scudder from America, eight genera being common to both. Of these seventy-one genera, thirty-seven are counted extinct, thirty-five from Europe, and two from America, none of these extinct species being found in both countries. The European genera are, as may be supposed, largely composed of amber species, no less than fifty-two, including thirty-two distinct genera, being confined to amber deposits, besides others which they possess in common with the stratified beds.[2]

Palpipes priscus[3] has been so long regarded as a Jurassic spider that I have alluded to it in this chapter, but that it is not a true spider, but

[1] Thorell, European Spiders, pages 223–233.

[2] Scudder, Tertiary Insects of N. A., page 51. I do not here include Eoatypus.

[3] Von Meyer, Palæontographica, Bd. X., pages 299–304, Taf. L., Figs. 1–4, Cassel, 1863.

a crustacean larva appears to me to be very clear from an examination of the figures which I reproduce, Figs. 385 and 386, and, indeed, this has already been shown by Seebach.[1]

V.

Geological Position of Florissant Spiders.

It remains to notice a little more definitely the geological position of the fossil spiders of America. Professor Cope, in view of the character of the fish fauna, relegates the Florissant deposits to the later Eocene or early Miocene.[2] Lesquereux, judging from the plants, refers this deposit to the lower Miocene or Oligocene.[3] This would place the spiders and the insects of these beds within the same horizon, substantially, as those of the amber and the Oeningen and other Tertiary strata of Europe. Or, as Scudder has expressed it, "We may therefore provisionally conclude, from the evidence afforded by the plants and vertebrates, that the Florissant beds belong in or near the Oligocene." The evidence derived from insects and spiders is thus in harmony with that from vegetables and higher animals.

I have attempted, by the following tabulated statement, to express approximately the relations of the Florissant spider bearing deposits with those of Europe in which spiders have also been found.

TERTIARY.			
	PLIOCENE.		
	MIOCENE.	Upper.	1. Fresh water formations, Oeningen, Switzerland.
		Middle.	2. Sulphur impregnated strata, Radoboj, Croatia.
		Lower.	3. Brown-coal strata of the Siebengebirge, Rhine.
	OLIGOCENE.		4. Florissant Basin, Florissant, Colorado, U. S.
			5. Amber, Prussian Baltic.
			6. Fresh water formations,[4] Aix, Provence.[5]
	EOCENE.		7. Garnet Bay, Isle of Wight (Eoatypus woodwardii).
CRETACEOUS.			
JURASSIC.			8. Lithographic limestone, Solenhofen, Bavaria (Palpipes priscus).[6]
TRIASSIC.			
PERMIAN.			
CARBONIFEROUS.			9. Argillaceous slate, Kattowitz, Upper Silesia (Protolycosa anthrocophila).
			10. Coal measures of Illinois (Arthrolycosa antiqua).

[1] Zeitschr. deutsch geol. Gesellsch, XXIII., page 340.

[2] Bull. U. S. Geological Survey Territories, 2d series, No. 1, 1875.

[3] Report U. S. Geological Survey Territories, Vol. 7, 1878. American Journal Science, XVII., page 279.

[4] Oustalet, Recherches sur les Insectes Fossiles des Terrains Tertiaires de la France, page 36. Oustalet presents the various views of geologists as to the position of this formation, from which I have placed it as here.

[5] A well preserved Theridioid spider from Aix may be seen in "Geology and Mineralogy," Bridgewater Treatise, by Rev. Wm. Buckland, D. D., Vol. II., page 79, and plate 46, Fig. 12, Theridium bucklandii Thorell. Gourret has recently described about eighteen Oligocene species from Aix. Rec. Zool. Suisse, IV., page 431, 1887.

[6] A crustacean larva, see above, page 457.

VI.

The fragile nature of the spider's spinningwork has passed into a proverb expressive of utter weakness and ephemeral age. Yet Mr. Scudder has uncovered for us a fossil cocoon, about one-fifth of an inch long, that dates from the distant period of the Oligocene, and which he describes under the name of Aranea columbiæ.[1] This cocoon has been found at widely separated points—Florissant, Green River, Wyoming, and British Columbia—and thus appears to have had some favored environment or especial qualities inducing preservation. One might suppose that the large cocoons of Orbweavers, especially those with tough encasements, like Argiope and Cyrtarachne, or the large flossy silken ball of Nephila, might easily have been fossilized under circumstances that allowed the preservation of the araneads themselves. None of these, however, have yet been discovered, and the little Aranea columbiæ cocoons are the sole representatives of the spinningwork of the aranead weavers of the Tertiary. Eleven of these in all have been found, and the survival of this minute bit of cocooning spinningwork is so interesting and important that I give a full abstract of Scudder's description thereof.[2]

Fossil Spinning-work.

Among the stones obtained by Dr. George M. Dawson in British Columbia are several containing the flattened remains of the egg cocoons of spiders. There are no less than eight of them, occurring by pairs, none of them reverses of others. They vary slightly in size, and more in shape, owing, no doubt, to their varying position when crushed; probably they were globular, or possibly slightly oval in shape; averaging about five millimetres in the longer and four millimetres in the shorter diameter; of a firm structure; testaceous in color, and hung by a slender thread, less or much less than quarter the length of the egg cocoon (averaging, perhaps, one millimetre in length), to a thickened mass of web, attached to some object or to the mother's web.

Fossil Cocoons.

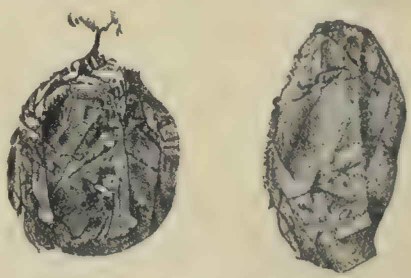


FIG. 387. FIG. 388.

The fossil spider cocoon, Aranea columbiæ.

FIG. 387. With the pedicle by which it was suspended. FIG. 388. Much elongated by pressure. Both figures are enlarged between five and six times. (After Scudder.)

That they have been preserved by pairs upon the stones has no significance, and, indeed, may be due simply to the way the stones were broken, for they lie at varying distances apart, with no sign of connection, and placed with no definite relations to each other.[3] Two of them show no

[1] First described in the Report of the Geological Survey of Canada for 1876–77, pages 463, 464. [2] See Tertiary Insects of N. A.

[3] Many spiders make two or more cocoons, which sufficiently accounts for the above fact.

sign of a pedicle, but this may be due to poor preservation; and a single one not only has no pedicle, but appears to be formed of a lighter, flimsier tissue, and may belong to a different species.

The egg cocoon of a spider of exactly the same size, shape, and general appearance as those described above, excepting that from a break in the stone there is no trace of a pedicle, was found by Scudder in the shales at Green River, Wyoming. A single specimen was also found at Florissant, Colorado, having the same general appearance, but with no trace of a pedicle and slightly larger than any of the others, being six millimetres long and four millimetres broad. It is, of course, impossible to say that it is the same species. Still another was brought by the Princeton expedition from Florissant, different in the opposite direction, being considerably smaller and so preserved as to appear broader than long. It is provided with a pedicle one and four-tenths millimetres long, but is itself only two millimetres long and two and a half broad.

Modern Types.

If the reader will turn back to pages 114 and 115, in the chapter on General Cocooning Habits, he will see examples of cocoons which correspond, both in size and general character, to these fossil cocoons of the Tertiary. Cocoons of Ero thoracica, for example (Figs. 111 and 116), are represented in my drawings about twice natural size; that is, they are about one-eighth inch long, or a little over three millimetres. They are suspended by a thread, from various objects, in a manner which is suggested by the character of Aranea columbiæ.

Another cocoon represented among these drawings (Figs. 112, 113) I there attribute to Theridium frondeum on the authority of Dr. Marx. A number of observations made since those pages were printed, both by myself and my secretary, have led me seriously to doubt the identification, and to believe that this little orange colored hanging cocoon, which has so long puzzled me to identify, is probably the cocoon of Theridiosoma radiosum. We have found it a number of times hanging close by the snares of females of that species in Belmont Glen and other ravines of Fairmount Park, and in the country surrounding Philadelphia; and no other species was found in the neighborhood to which such a cocoon could be attributed. I am therefore inclined at the present date to believe that the Ray spider is responsible for this pretty little egg sac. In addition to this, I have examined young specimens raised from the cocoon, and although the determination of a species by just hatched spiderlings is well known to be extremely uncertain, yet this examination has confirmed me in the above opinion. The shape of cephalothorax and abdomen, arrangement of eyes, proportion of legs, and general ensemble of the younglings lead me to conclude that, if they are not Theridiosoma, they belong to no species with which I am acquainted.

Theridiosoma Cocoon.

In further confirmation I may add that Dr. L. Koch says of the cocoon

of Theridiosoma gemmosum that it is pyriform, pediculated, of yellow brown color, with pedicle white, and that the female makes her cocoon at the end of June.[1] This description well agrees with the cocoon under question. Simon himself says that Theridiosoma gemmosum is found along the borders of waters, making its snares upon aquatic plants. Its cocoon is in the form of a balloon, with a pedicle like that of Ero.[2] As Theridiosoma gemmosum and T. radiosum are probably identical, or at least closely related, this evidence appears to be almost conclusive.

I have measured many of these Theridiosoma cocoons, and they average in length about one-eighth inch, or, more accurately, three and one-half millimetres. Their width is a little less. In other words, the cocoon is almost spherical, but the addition of the pedicle or stalk makes it seem longer. I have seen some cocoons which were five millimetres long. Theridiosoma's cocoons are closely woven and of tough fibre, well fitted for preservation. If now we compare the above named structures with Scudder's fossil cocoons, we shall find a close resemblance. We may therefore have little hesitation in relegating Aranea columbiæ to some such Theridioid genus as Ero or Theridium, or perhaps to the ancestors of Theridiosoma. The Ray spider has evident relationship to Theridium, as appears from the fact that such accomplished araneologists as Cambridge, Simon, and the late Count Keyserling have classed it with the Retitelariæ. One might therefore venture to attribute to it an ancient lineage, and even to risk the conjecture that a species of Theridiosoma may have been the author of some of Scudder's fossil cocoons.

Unmodified Industry.

The preservation of any spinningwork through so vast a period is greatly interesting; but I find the chief value of the fact in the inference that the general habits of spiders have followed even more closely the law of unmodified survival that appears to mark the general structure of araneads. Indeed, I am not able here to note any difference. Precisely the same industry that we see everywhere exemplified in the pretty hanging basket cocoonery of our modern Ero, Theridium, or Theridiosoma, characterized the fossil Aranea columbiæ that wrought her spinningwork along the shores of Lake Florissant in the early period of the Tertiary. It is certainly not an unwarranted inference that the spinning organs by which these cocoons were produced differed in no essential particular from those possessed by modern spiders.[3] This likeness implies structural similarity in other vital organs, and hence, reasoning from industrial product to function, from function to organ, from special organs to general structure, we arrive at the same conclusion that seems justified by a study of Scudder's American fossils, that many spiders of the Tertiary were not widely different

[1] Simon, Arach. de France, Vol. V., page 27. [2] Ibid., page 25.

[3] See Vol. I., Chapter II.

generically, and some probably even specifically, from the spiders which now inhabit our continent.

VII.

The Amber Tree.

Since most fossil spiders known to us are preserved enclosed in amber, it is important in our study of the life of ancestral araneads to know something of the history and character of this important substance. Amber is a product of the prehistoric world, a hardened resin which issued from the bark of certain trees. The chief geographical source of the amber wood is in the bottom of the Baltic Sea in the neighborhood of what is now called Samland, near Pillau. The amber tree is known as Pinites succinifer Göpp. and Ber., and has been described from various vegetable inclusions—wood, blossom, fruit, and needle leaves—along with various insects and araneads. The species Succinifer rightly belongs to the genus Pinus, although that name is really a collective name, inasmuch as included needle leaves and other vegetable formations show there must have been at least four species of pine in the amber fields. Since it cannot be determined which one of these actually secreted the resin, the specific name must be a comprehensive one. The trees which produce the amber are not now known to exist, but Berendt says that the Balsamea most closely resembles it.[1]

Every gale from the north still throws up, as for unknown ages it has done, masses of amber on the shore of the Baltic Sea, and each point of the coast is said to receive a particular kind so peculiar that practiced cutters are able, when looking at a rough piece, to decide whether it came from a quarter to the east of Danzig or from the west on the coast of Pomerania; they are therefore probably the product of different trees.

Sources of Amber: Samland.

The sources of amber are submarine forests which, in the middle epoch of the Brown-coal, as Berendt conceives, covered the shores of an island continent that occupied the northern portion of the great Tertiary sea that covered most of Germany. This island, or group of islands, had its geographical centre in the southeastern part of the present sea basin, under the fifty-fifth degree of latitude, and its northwestern border extending higher than the present northwestern point of Samland.

The name Samland will not be found upon many maps, and it may, therefore, be defined as distinguishing that part of Prussia bounded on the west by the Baltic Sea; on the north in part by the same sea, the Kurische Nehrung, and Kurische Haff. The southern boundary is the river Pregel and the Frische Haff; while the eastern boundary is an arm of

[1] Berendt, G. K., Die im Bernstein befindlichen Organischen Reste der Vorwelt gesammelt in Verbindung mit Mehreren bearbeitet und herausgegeben, von C. L. Koch und Dr. Georg Karl Berendt. Band I., Abth. II., page 28, Berlin, 1854 (1845).

the Pregel, the Deima. It is hilly towards the northwest, the ground rising to heights of two and three hundred feet, and becoming flat towards the northeast and east, and gradually sinking down towards the northeastern angle. In the elevated northwestern coast Tertiary beds are conspicuous at a height from eighty to one hundred and twenty-five feet above the sea level, in which amber deposits are found.

Amber Bay.

Zaddach[1] defines the site of the amber forests as a bay whose bed included the whole of West Prussia, a neighboring portion of Pomerania, and the western half of East Prussia, and which was connected in the southwest with the great Tertiary sea that covered the larger portion of Germany. The northern boundary of this bay left Samland at some distance, and was continued westward with some irregularity to Ruckshöft (Rixhöft), which lies at the foot of the peninsula of Hela, and where thick Brown-coal beds crop out on the coast of the Baltic. The bay was a basin in the Cretaceous formation, and was bordered by widely extended flat coasts, which mark the last upheaval of the district. Numberless rivulets with small discharge emptied themselves into the bay and carried solid matter into it, and another stream from the northwest, which flowed from the southern portion of the Cretaceous land, also discharged itself here.

Trees Running Amber.

The coasts of this bay were covered with luxuriant plant growths, a flora whose delicate structure is still preserved to us in the amber and coal. The forests which covered the shores of this bay and occupied the group of islands or insular continent beyond, were, according to Zaddach, the native home of the amber. This amber resin issued from the trees as pitch issues from pine trees, and gum from our cherry and plum trees. In the Adirondack forests I have seen guides and visitors collecting vials full of the aromatic resin which issues from the fragrant balsam tree. Certain resins and gums of commerce, as copal, anime, benzoe resin, mastix, and balsam, are collected by making slits in the bark of trees so that the resin runs down in channels to the ground, where it hardens and is collected for transportation. Copal perhaps affords the best analogy between modern resins and the ancient amber, because it comes nearest it, and, indeed, according to Berendt, may be considered its modern representative. One species of copal belongs to the prehistoric world, but Berendt thinks that it did not grow in the same native home with the amber tree, because the organic inclusions of the two resins show no identity.

The great amount of amber already collected gives but slight indication of the incalculable quantity that must have been secreted by the amber pines of the Tertiary. The sunken storehouse thereof, the former

[1] Amber: Its Origin and History as illustrated by the Geology of Samland, by Dr. G. Zaddach, Professor in the University of Königsberg. Quarterly Journal of Sciences, London, 1868, page 167.

soil of the forests, seems to be full of it. Although storms and floods during thousands and thousands of years have been tearing up and washing away these stores, the quantity seems to have been lessened to only a trifling degree. All the Baltic shores which lie closest to this supposed sunken continent, also the west shore of Samland and the north shore of the Frische Nehrung, have always received and still receive a large quantity of amber. However, the storms from the west and west northwest bring up the amber most abundantly.

Vast Amber Stores.

The temperature was then much higher than now, and the flora of the amber continent contained certain northern forms associated with plants in temperate climate, and others whose nearest allies now live in much more southern regions. Thus camphor trees (Cinnamomum polymorphum Heer) occur with willows, beeches, and numerous oaks. Among the conifers, the most abundant tree was a Thuja, very similar to the Thuja occidentalis now living in America, next to which abounded Widdringtonia, pines and firs in great variety, and among them the amber pine. Many of the last already had perished, and, while the wood decayed, the resin with which the stem and branches were stored might have accumulated in large quantities in bogs and lakes in the soil of the forest.

In order to explain, however, that this accumulation of amber could be suddenly broken up, floated away, and scattered, Zaddach assumes that the coast of the district was on the point of sinking. Alternate upheavals and depressions of the country may be positively proved to have occurred in the immediately succeeding period. If at that time the coast sank but slowly, in the lapse of a few centuries, or even a shorter time, a great portion of the flat coast terraces might have been covered by the sea. The forest earth was washed up by the waves, and the amber carried into the sea. The greater portion being probably still attached to the wood, with all its animal enclosures, it could float about in the water for some time before sinking. The forest of the inundated coast was also destroyed, but the stems of the trees which floated out into the open sea were scattered about, only those pieces of wood imbedded in the amber charged earth sinking with it to the bottom. Thus perished the amber forests; in great part, at least, for one need not assume that they were then all destroyed, as it is probable that in the higher districts of the country there still remained many forests which also were rich in amber trees.[1]

Breaking up the Storehouse.

At last, after alternate upheavals and depressions, the land gradually rose to its present height. And now, when lashed by storms, the sea tears up the amber out of the deep lying beds of amber earth. By the help of sea weeds turned up at the same time, the resin is heaved upwards and

[1] Zaddach, op. cit.

carried on the surface of the water; and when the storms abate and the sea becomes calm it carries the amber, together with pieces of older Brown-coal and fresh marine plants, on to the beach, where a hundred hands are waiting to intercept it with nets. That is the "amber drawing," a trying occupation, which demands a strong and hearty frame, for the cold winter storms yield the richest booty. But many pieces of amber, nevertheless, do not reach the shore, for the largest and heaviest pieces have already sunk to the bottom, and lie between the large boulders which cover the sea bed. Therefore, in calm weather, the inhabitants of the coast take boats and turn the stones with hooks fastened to long poles, dislodge the amber in the interspaces, and draw it up with small nets. This is called "striking for amber" (Bernstein strechen).

Collecting Amber.

Amber is occasionally met with in the gravel beds near London. At Alborough, on the coast of Suffolk, after a wrecking tide, it is thrown on the beach in considerable quantities along with masses of jet, and if not torn from the bed of the sea may have been washed from the Baltic. There are regular mines of amber in Spain, and it is also abundant on the shores of Sicily and the Adriatic Sea.

According to Mr. Hope, who speaks as an entomologist, many of the insects recognized in amber indicate a tropical climate, and evince a South American relationship; yet the Blattidæ and some of the Hymenoptera resemble closely oriental species. The presence of many other genera indicates a northern climate. From the above discrepancies, it may be adduced that the climate and temperature of Europe have undergone considerable change. The examples of tropical insects sufficiently testify that the amber tree did not flourish in a climate such as Prussia now enjoys, but in a warmer region.[1]

Climate of Amber Land.

VIII.

One who reads a list of Succinic Insects, as, for example, that published by Mr. Hope,[2] will find represented the orders of insects with which we are now familiar. These must have formed the food supplies of the amber spiders. A large proportion of our common families are therein represented, and underneath these families numerous genera of prevalent insects appear. It would thus seem that the generic aspects of the insect fauna of the amber period resembled that of the present time; indeed, Mr. Hope has said, perhaps somewhat too strongly, "the major part exhibit a close resemblance

Insect Food of Amber Spiders.

[1] Rev. F. W. Hope, F. R. S., President Entomological Society. "Observations on Succinic Insects." Transactions Entomological Society of London, Vol. I., 1836, page 133, sq.

[2] Ibid., pages 139, 147.

to existing species, and can be satisfactorily placed under the published genera." However, we have not been able to trace specific identity. In this antediluvian and amber forest now lying beneath the North Sea waves, and along the shores of this Tertiary Amber Bay, we can readily picture to ourselves vast numbers of Coleoptera burrowing in the ground, boring in trees, flying among the branches, pursuing the same round of habits with which we are to-day familiar. The Homoptera are represented by the Cicada, who doubtless then as now filled the forest with his piping notes. Dragon-flies hunted their insect prey, and Libellula and Agrion carried havoc among the entomological hosts, as they do to-day in the neighborhood of Philadelphia. Ichneumon flies doubtless exercised their parasitic habits upon victims like their modern hosts. Wasps of various sorts dragged numberless spiders, flies, and other insects into their mud daub nests to feed their voracious grubs.

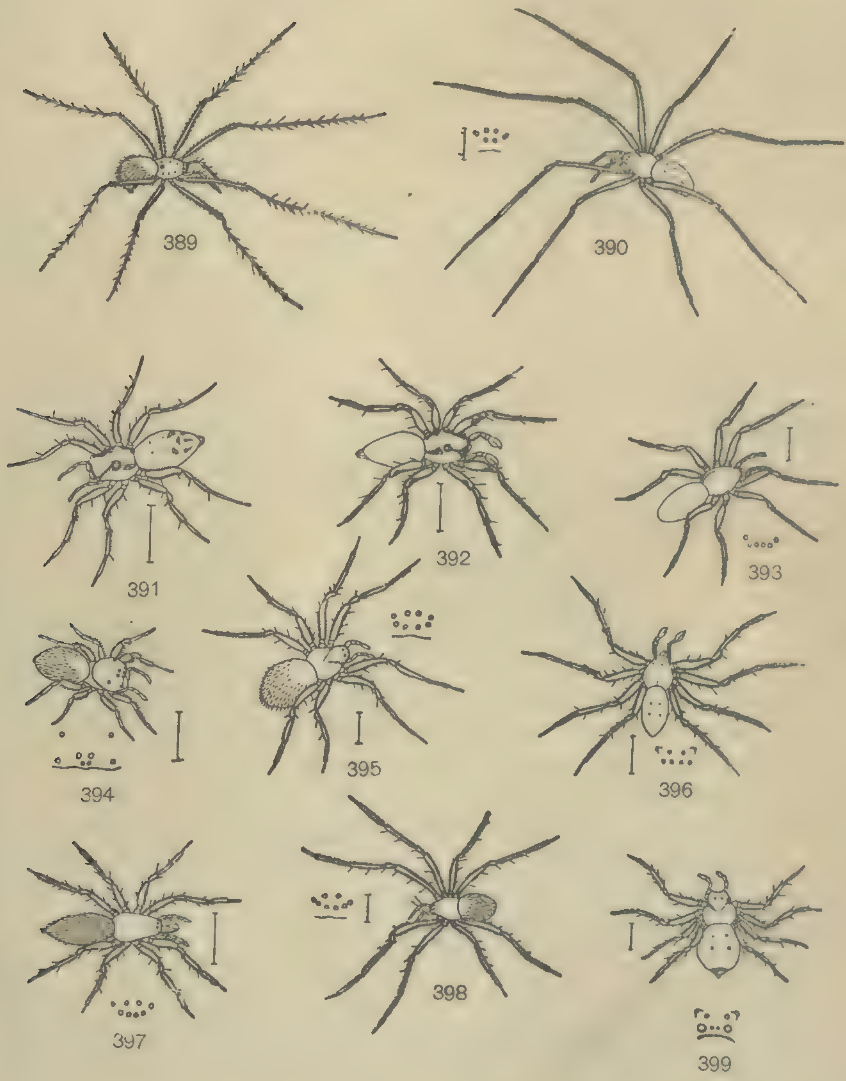
Ants and bees were present in great numbers. Among the Orthoptera, cockroaches, locusts, grasshoppers, and many other genera were represented. Among the Lepidoptera such well known genera as Papilio, Tinea, and Sphinx might have been seen; and minute Diptera, some of which, at least, were similar to those of modern Europe, everywhere abounded in field and forest. We may, therefore, conclude that the picture of this submarine antediluvian amber forest, which we can draw from the facts presented to us by the entomologist, botanist, and geologist, would not largely differ from that of the midsummer aspect of the forests of the Adirondack Mountains in New York, where various sorts of pine trees reach immense proportions, and the balsam especially abounds, forming the fragrant upholstery for the beds of those who bivouac or camp along the lakes and rivers of that favorite region of American summer tourists. In the midst some such scenes, and surrounded by similar insect hordes, the aranead ancestors of our existing spiders dwelt. The reader may know just how they looked. They are embalmed for us in the liquid resin secreted in the forests of Amber Island and Amber Bay.

On the accompanying full page engraving I have presented a few selections from the figures of amber spiders, as given in Berendt's noble work.

Amber Spiders.

Figs. 389 and 390 represent Orbweavers of the genus Zilla. The Lineweavers are represented by Figs. 395 and 398, Ero and Theridium. The Tubeweavers by Figs. 393 and 397, Segestria and Clubiona. The Saltigrades, by the unmistakable Eresus at Fig. 394, and the Laterigrades by Philodromus and Syphax, Figs. 396 and 399. It is at once manifest by a glance at these drawings that in their general facies not only, but in their detailed characteristics, they show a close resemblance to corresponding genera as they are known to-day.

This resemblance, however, to existing genera (as far as now known) is not always so apparent from the figures presented by Berendt. For example, Archea paradoxa, which is represented much enlarged in both the



Fossil spiders of the amber. (After Berendt.)

FIG. 389. Zilla porrecta, female. FIG. 390. Zilla gracilis, female. FIG. 391. Phidippus frenatus, female. FIG. 392. Phidippus frenatus, male. FIG. 393. Segestria nana, female. FIG. 394. Eresus monachus, female. FIG. 395. Ero setulosa, female. FIG. 396. Philodromus microcephalus, male. FIG. 397. Clubiona attenuata, female. FIG. 398. Theridium hirtum, female. FIG. 399. Syphax megacephalus, female.

female form (Fig. 400) and the male form (Fig. 401), shows a wide divergence from any spider with which I am acquainted. Modern spiders certainly present some forms that are equally remarkable in their divergence from the typical spider facies. But this genus appears to stand by itself, without any modern representative, and is probably extinct.

Embalming Amber Insects.

As the climate of the amber forests covering the shores of the Tertiary Amber Bay, and the islands grouped within it, was that of a semitropical rather than of a temperate zone, we may conceive these endless woods of amber pine exuding streams of resin under a hot summer sun. The liquid product freely flowed down the trunks of the trees and accumulated in great lumps around the roots, mass mingling with mass, as the trees stood close together in the forests, until in the course of time the soil was surcharged with solidified resin. In that period, as now, insects frequented trees, and were continually hovering around the trunks, alighting thereon, creeping along the bark. Then, too, any aromatic substance dropping from the branches upon the ground must have attracted swarms of them, as I have often seen in American forests.

Fig. 400. The fossil spider Archea paradoxa; female. (After Berendt.) Natural size shown in the circle.

We have thus the conditions under which the amber fossils were entombed; for a single touch of an insect upon the liquid resin would at once arrest its flight, and the soft, flowing stream would instantly imbed it. For the most part this enclosure seems to have been painless; at least, the attitude of the included insects and spiders is such as to suggest the absence of all violent struggle. At any rate, their limbs soon sank into a position of repose, and they are thus preserved to us.

Spiders Embalmed.

Where insects are, there spiders resort in search of their natural food. Lurking upon the branches, crouching, walking, jumping upon the trunks, spinning their webs in the grasses at the foot of trees, and stringing them from bough to bough, it is not strange that, in the ordinary course of life, they too found sepulture within the liquid runlets and masses of resin, and thus have been preserved to us, along with the insects whose lives they sought, imbedded in amber.

One might well be excused for giving his imagination some play in depicting the strange mutations of these creatures of the amber forests. But the simple truth seems fanciful enough. Their life in those fragrant woods of the Tertiary, along the islands and shores of the ancient Tertiary sea; their swift entombment within the aromatic balsam; their long repose within the soil of the ancient forests; the convulsions by which they were sunk deep within the sea, and their recovery again to the surface; their final repose in the deep bed of the Baltic Sea, after the recurring depressions and elevations had ceased; in some cases, at teast, their settlement and subsidence, after drifting here and there, attached to broken and decayed trunks and roots, the sport of waves and currents of the ocean; their long, long sleep underneath deep sea waves, while the marvelous changes that have made our present world were being wrought out; their rupture from their rest of milleniads by the grinding force of winter storms; their drifting before the force of breaking waves upon the shores of Samland; their capture by the fishermen and amber strikers of Germany; their cutting, shaping, and polishing in the hands of lapidaries; their transit from hand to hand among venders and merchants; their resting place in cabinets of entomologists, collectors, and scientific societies; their voyage from country to country, and once more upon the sea; their lodgment here beneath the curious eye and lens of the writer, who studies them and depicts their forms for science as they rest embalmed in their amber sarcophagus—all this is certainly a picture upon which fancy might fondly dwell. It reads like a romancer's tale; yet the story, nevertheless, presents no merely fanciful features, but, in good sooth, is all within the realm of sober facts which naturalists have disclosed.

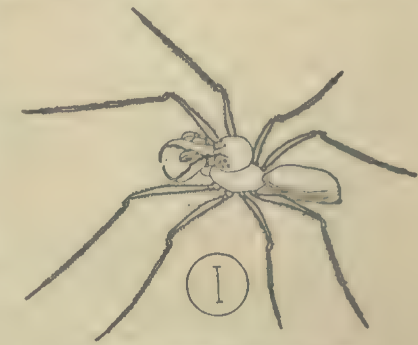


FIG. 401. Arachea paradoxa; male. (After Berendt.)

Resurgam.

THE END.

INDEX OF VOLUME II.

SUPPLEMENTARY LIST OF SUBSCRIBERS.[1]

Prof. Aug. Weismann, Freiburg, Baden, Germany.
Isaac C. Martindale, Philadelphia.
Public Library, Bangor, Maine. (Mrs. M. H. Curran.)
Hon. J. K. Valentine, Philadelphia.
Lieut. Col. Linley Blathwayt, Bath, England. (William Wesley & Son, London.)
Feret & Fils, Bordeaux, France.
Prof. A. Agassiz, Cambridge, Massachusetts.
R. C. McMurtrie, Philadelphia.
Alfred C. Harrison, Philadelphia.
Col. A. K. McClure, Philadelphia.
George C. Thomas, Philadelphia.
Carl Edelheim, Philadelphia.
Rev. W. C. Cattell, D. D., LL. D., Philadelphia.
Gen. I. J. Wistar, Philadelphia.
Dr. J. B. Brinton, Philadelphia.
Koenigliche Bibliothek, Berlin, Germany.
Kaiserliche Universitäts und Landesbibliothek, Strassburg, Germany. (Otto Harrassowitz, Leipzig.)
State Laboratory of Natural History, Champaign, Illinois.
Conyers Button, Philadelphia. (Two copies.)
The Signet Library, Edinburgh, Scotland. (Thomas G. Law.)
W. B. Clark & Co., Boston, Massachusetts. (Two copies.)
Dartmouth College, Hanover, New Hampshire. (Charles F. Richardson.)
Charles Schaffer, Philadelphia.
Rev. F. O. Pickard-Cambridge, Carlisle, England. (William Wesley & Son, London.)
Enoch Pratt Library, Baltimore. (Lewis H. Steiner.)
Justus C. Strawbridge, Philadelphia. (Two copies.)
Haverford College, Haverford, Pennsylvania.[2]
Librairie, H. Georg, Geneve, Switzerland.
Edinburgh Public Library, Scotland. (Hodder & Stoughton, London.)
Mrs. Henry Draper, New York City.
J. B. Lippincott Co., Philadelphia.
Providence Athenæum, Providence, Rhode Island. (Daniel Beckwith.)
University of Minnesota, Minneapolis. (Prof. Henry F. Nachtuit.)
State Library of Pennsylvania, Harrisburg. (Porter & Coates, Philadelphia.)
Mrs. Emma W. Bucknell, Philadelphia.
John MacFarlane, Detroit, Michigan.
James Kelly, New York City.
Entomological Society of Ontario, London, Ontario, Canada.
University of California, Berkeley, California. (Methodist Book Depository, San Francisco.)
Kegan Paul, Trench, Trübner & Co., London, England.
A. S. Bertolet, Cummings, Illinois. (A. C. McClurg & Co., Chicago.)

---

[1] This list includes all subscriptions made since November 1st, 1889. All before that date are published in Volume I. The author wishes to print a complete and corrected list at the close of Volume III., and requests that any mistakes heretofore made may be communicated to him. He also requests all subscribers to send their names and addresses in full, with proper titles of individuals and full names of societies, libraries, etc.

[2] Presented by Mr. Justus C. Strawbridge.